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DEPARTMENT OF DEFENSE

Materiel Distribution System Study

Volume 3. Book 5.
Appendix D-3. Depot
Cost and Capacity.

PREPARED FOR THE

JOINT LOGISTICS COMMANDERS

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VOLUME III, BOOK 5
APPENDIX D-3, DEPOT COST & CAPACITY

[redacted]

DEPARTMENT OF DEFENSE
MATERIEL DISTRIBUTION SYSTEM STUDY
(DODMDS)

VOLUME III, BOOK 5

APPENDIX D-3

DEPOT COST AND CAPACITY

CONTENTS

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SECTION 1
INTRODUCTION

The objective of the DODMDS study was to review and analyze the current DODMDS and to recommend alternatives to optimally integrate, consolidate, and/or standardize distribution system functions and facilities. In order to meet that objective the DODMDS study group assembled a logistics data base which represented one year's worth of DOD supply transactions. Analysis of the DOD logistics data base was conducted with the assistance of two mathematical models; an optimization model and a simulation model. The optimization model examined various DODMDS system structures in an economic framework while the simulation model validated the dynamics of the various hypothesized system structures. This appendix describes the research, analysis, and methodology that were undertaken to formulate input data to represent the DODMDS supply depots in the two DODMDS study group models. The models recognize individual supply depots only in terms of depot variable and fixed cost and storage/throughput capacity data.

Depot variable cost data were developed for model evaluation under two independent but related concepts, baseline and nominal. Baseline depot variable cost rates (in $/CWT) were developed from historical accounting reports in conjunction with the DODMDS study group transactional data base. The development of baseline depot variable cost rates required three distinct phases:

(1) Extraction and validation of historical accounting system data.

(2) Development of historic depot workload.

(3) Joining of the cost and workload data.

Each of these phases are delineated in Section 2 of this appendix, along with the development of depot fixed cost. Sections 3, 5, and 6 of this appendix address the methodology and techniques used to develop nominal depot cost data. A nominal depot represents a conceptualization of a depot receipt, storage and issue operation utilizing new state-of-the-art materiels handling equipment and facilities. The nominal depot costs differ from the baseline depot by reflecting the use of optimum labor scheduling and control of direct "hands on" labor, more economical mix of space, equipment and labor, and the capability of supporting any throughput level or commodity mix. Nominal depot cost data was constructed to reflect both current state-of-the-art and FY 1986 forecasted materiels handling technologies.

Section 4 of this appendix explains the methodology and data bases used to represent the physical storage and processing capabilities of the DODMDS supply depots in the modeling effort. Depot capacity in annual throughput and storage requirements were developed for use in formulating and evaluating alternative system structures. Daily depot capacity was developed in line items and weight to examine the dynamic aspects of the hypothesized system structures.

Sections 5 and 6 of this appendix were prepared by Drake Sheahan/Stewart Dougall, Inc. under contract N00600-76-C-0508.

SECTION 2
BASELINE

A. INTRODUCTION

This section describes the methodology, assumptions and techniques used to establish the DODMDS historical depot cost and depot workload and to convert these data into a form usable for the modeling effort. This section also describes the methodology for developing data used in various sensitivity analyses and data required to evaluate the distribution/ maintenance interface.

B. BASELINE DEPOT COSTS

1. The Goal

The goal in developing baseline depot costs was to produce data which could be used in a methodology for predicting how realignment of distribution workload would impact on the depot costs associated with accomplishing materiel distribution in the DOD. To do this, historical depot costs had to be derived to establish a baseline and, second, baseline costs had to be transformed into model input data in the form of variable cost per hundredweight (CWT) of DODMDS product per depot and fixed cost per depot. This section explains the derivation of baseline costs as shown in Tables C-7.1 through C-7.25, Appendix C, Section 7, for each of the 34 DODMDS depots under study.

2. Two Costs

There are essentially two types of depot costs incurred to accomplish materiel distribution:

a. The costs incurred by the distribution organization to perform materiel distribution workload, i.e., receipt, store and issue of materiel.

b. The costs incurred by installation level organizations to support a distribution mission.

In brief, baseline depot costs related to materiel distribution workload were derived from the cost data reported in accordance with DODI 7220.17, cost Accounting for Central Supply Management, Industrial Preparedness, and Terminal Operations. Baseline depot costs related to installation support were derived from installation level costs allocated to individual distribution missions.

3. <u>Distribution Workload Costs</u>

For the first type of depot cost, the majority of annual recurring Operations and Maintenance (O&M) costs for distribution functions as performed by DOD supply depots are reported within the framework of the individual Service/Agency accounting systems established in accordance with DODI 7220.17.

a. This instruction requires that depot costs be collected and reported by functional areas related to Five Year Defense Plan (FYDP) Program Element (PE) 71111, Supply Depots/Operations (SDO). Each general functional area within SDO is subdivided into a series of cost accounts which describe specific functions within the general functional area. For example, storage and warehousing is composed of individual accounts for receipt, pack, bulk issue, bin issue and ship functions. The study group focussed on the SDO costs incurred for wholesale materiel distribution in the following general functional areas: (1.1) Storage & Warehousing, (1.3) Traffic Management, and (1.9) Overall Supply Depot Support. Disposition of (1.2) Stock Control, (1.4) Air Terminal Operations, and (1.5) Waterfront Operations functional accounts are discussed under cost exclusions in Exhibit 2-1, pages 2.62 through 2.84.

b. The purpose of the DOD Instruction is to standardize the terminology and structure for accumulating and reporting costs for DOD activities involved in materiel distribution. Implementation by each Service and DLA of the standard cost account structure for SDO reflects the individuality of each Service/DLA. The initial survey of SDO reported costs revealed that the costs as reported by the Services and DLA could only be used as a starting point for deriving comparable baseline costs for the 34 depots. Table 2-1, page 2.4, provides a list of account series and organization symbols used to designate SDO functional accounts by the Services and DLA. Use of the cost data reported IAW DODI 7220.17 to develop baseline depot costs required that the following key differences be recognized and reconciled:

(1) Accounting Systems. The most basic cost comparability problem centers around which costs are recorded against which DODI account. Packing supplies were charged to the packing account by some and to a support account by others. The receiving account includes documentation processing at some depots but not at others. Differences like these made it necessary for the study group to view SDO cost accounts in aggregate and not attempt comparisons of individual cost accounts. Additionally, accounting system idiosyncracies result in the presence of costs irrelevant to wholesale materiel distribution being reported in SDO costs. The classic example is the DOD Dog Center at San Antonio ALC being charged to Overall Depot Support (DODI 7220.17 account 1.9).

(2) Secondly, some materiel distribution functions are performed outside the distribution organization. At the NAS's and MCAS Cherry Point, for example, Preservation and Packaging (P&P) was performed by the Naval Air Rework Facility (depot maintenance) rather than the distribution organization. The charges were borne by the ICP as an integral part of the cost of the materiel repair process.

SERVICE/AGENCY	RESPONSIBLE HEADQUARTERS	DEPOT	ORGANIZATION PERFORMING SDO	ACCOUNT SERIES	PUB
ARMY	DARCOM	Army Depot (AD)	Directorate of Supply	721111.100 721111.200 721111.300 721111.900	AR 37-100-75 with AMC Sup 1
NOTE:	Accounts in 100, 200 and 900 series are subdivided between ammo and general supplies. Quality and Overall Depot Support are subdivided into more detailed accounts.				
NAVY	COMNAVAIRLANT COMNAVBASENORVA COMNAVAIRPAC	Naval Air Stations (NAS)	Supply Department	2100 2200 2300 2400	NAVCOMPT Manual Vol II
NOTE:	NASs exercise local management prerogatives to use additional cost accounts to a limited degree.				
NAVY	NAVSUP	Naval Supply Centers (NSC)	Materiel, Freight Terminal and Inventory Control Dept.	2100 2200 2300 2900	NAVCOMPT Manual Vol II and NAVSUP Pub 285, Chapter 5, Part B
NOTE:	NAVCOMPT Manual, Vol II added accounts for materiel screening and outfitting of ships. NAVSUP Pub 285 subdivided some NAVCOMPT accounts into more detail and added accounts for special projects.				
AIR FORCE	AFLC	Air Logistics Center (ALC)	Directorate of Distribution (DS)	Same as DODI 7220.17	AFLCM 177-8
NOTE:	Four AFLC unique accounts added to the DODI structure				
MARINE CORPS	HQ USMC	Marine Corps Air Station (MCAS Marine Corps Logistics Support Base (MCLSB)	Supply Department Materiel Division	2100 2200 2300 2400	NAVCOMPT Manual Vol II
NOTE:	The MCLSBs use two sets of 2000 series accounts: one for worldwide supply operations, the other for local consumable material supply operations.				
DLA	HQ DLA	Defense Supply Centers (D-SC) and Defense Depots (DD--)	Storage & Transportation	300	DLAM 7000.1
NOTE:	DLA established accounts within the 300 series for Depot Maintenance, contractual operations, and Industrial Plant Equipment.				

Table 2-1. Services/DLA Account Series

(3) The third difference caused the largest impact on reported costs; it involved the diversity of distribution tasks assigned to individual depots due to the materiel distribution philosophies (missions) of the Services and DLA. These tasks include functions like on-base retail customer support at Navy, Marine Corps and Air Force depots, depot maintenance interface at most Service depots, air cargo operations at ALC's, water cargo operations at NSC's, Container Consolidation Points at New Cumberland, Red River and Sharpe AD's, Maintenance Support Package Operations at Norfolk and North Island NAS's, and Industrial Plant Equipment (IPE) at DCSC Columbus, DDMP Mechanicsburg, and DDTC Tracy.

c. The collective effect of these Service/Agency differences on data reported IAW DODI 7220.17 produced two problems which had to be resolved:

(1) There were costs reported as SDO costs which had to be excluded from the reported depot cost data.

(2) Costs for certain production functions were not reported as SDO costs and therefore had to be derived and added to baseline costs.

d. The first problem was solved by developing five DODMDS-derived exclusion rules for data base construction:

(1) Non-SDO Costs. Where accounting system/organization structure differences resulted in costs of functions not related to materiel distribution functions being reported within the SDO cost structure, the costs were excluded. Examples are the DOD Dog Center at SAALC and Library Operations at NSC Norfolk.

(2) Non-comparable SDO Costs. Where Service/Agency unique distribution tasks, e.g., manifested water cargo (Military Traffic Management Command reimbursed) operations at NSC's and Maintenance Support Packages (MSP) at two NAS's, resulted in SDO costs which cannot be compared with SDO costs as reported by other Service/Agency depots, the costs of the unique tasks were excluded.

(3) DODMDS Policy. The exclusion of ammunition, bulk petroleum, and perishable subsistence items from DODMDS consideration placed these commodities outside the scope of the model analysis. Therefore costs associated with depot processing of those items were excluded from depot cost functions.

(4) Non-study DODI Accounts. Four DODI prescribed accounts, 1.142 - Customer Service Store, 1.32 - Passenger Processing, 1.33 - Household Goods, and 1.42 - Air Passenger Processing were considered by the DODMDS study group as non-wholesale materiel distribution functions and therefore excluded.

(5) One-time Expenses. Costs incurred for special projects, e.g. modernization, rewarehousing, contractual storage, etc., were excluded from depot cost functions used for long range planning since one time expenses tend to distort individual depot costs.

e. The application of these rules to the cost data reported IAW DODI 7220.17 by both DODMDS and cognizant logistics headquarters personnel produced the excluded cost data contained in Exhibit 2-1, pages 2.62 through 2.84. This exhibit is divided into five parts, one part for each Service and DLA. Depots are identified by abbreviated name, DODMDS study group sequence number and two-digit DODMDS Routing Identifier Code (RIC). The excluded functions in each part are grouped by the above rules. Each part contains explanations for the exluded functions.

f. For the second problem, that is, where materiel distribution costs were incurred, collected, and reported outside of the DODI 7220.17 account structure, an ad hoc procedure was derived to capture the costs. Costs for the Preservation and Packaging (P&P) function at the NAS's and the MCAS Cherry Point were estimated by DODMDS study group using P&P data submitted as part of the 32-day census portion of the DODMDS Data Call (RCS: DD-I&L (OT) 763). P&P labor rates and materials and supplies were calculated internally as detailed in Exhibit 2-2, pages 2.85 through 2.87.

g. The culmination of these efforts was the baseline SDO costs for materiel distribution functions identified as handling, storage, and supply support as follows:

(1) Supply Handling Costs:

Supply Handling Costs	DODI 7220.17 Account
Receiving	1.11
Packing	1.121
Bulk Issue	1.122
Bin Issue	1.123
Shipping	1.124
Inspection	1.143
Receipt Documentation	1.2
Freight	1.31

(2) Supply Storage Costs:

Supply Storage Costs	DODI 7220.17 Account:
Care of Materiel in Storage	1.131
Rewarehousing	1.132
Preservation & Packaging	1.133
Container Fabrication	1.134
Unit and Set Assembly	1.135
Physical Inventory	1.136

(3) Supply Support Costs:

Supply Support Costs	DODI 7220.17 Account:
Packing & Issue Support	1.129
Personnel Training	1.137
General Storage Support	1.139
General Storage & Warehouse Support	1.19
Personnel Training/ Transportation	1.34
Traffic Management Support	1.39
Overall Depot Support	1.9

h. This grouping of functions appears in Appendix C, Section 8, Tables 8-1 through 8-25 along with costs referred to as Supply Overhead. The Supply Overhead costs are composed of the second type of depot costs needed to complete the baseline.

4. Installation Support Costs

The second type of costs needed to derive the baseline was the cost for support services provided to the distribution organization by installation level organizations. The "scrubbed" accounting data discussed above represents the DOD costs directly attributed to the materiel distribution mission, Program Element 71111[1]; however, these data do not represent the total cost to DOD of performing the mission. Materiel distribution, like any other logistics or operational mission, incurs costs at the installation where it is performed. The installation organizational structure is designed to provide common services to the various missions being conducted at the installation. These services are by definition not related to the specific functions performed by individual missions but are essential to the conduct of each mission. In FY 1975 the Services and DLA funded the common service support structure under, for example, Program Element 72896, Base Operations. The costs incurred in providing common services are not charged to distribution mission elements except in the case of Army depots operating under the Army Industrial Fund procedures. For Army depots, many of the installation common services are routinely charged to supply or maintenance missions through indirect and general administrative expense rates. Developing comparable estimates of the costs associated with installation common services applicable to materiel distribution functions presented a twofold problem. In the Army case, a comprehensive review of cost reporting in accordance with Army Industrial Fund procedures was conducted in order to stratify Army depot costs into DODMDS study group categories in Appendix C, Section 8, Tables 8-1 through 8-25. For the other Service and DLA depots, a means had to be derived to estimate these same installation services costs.

a. The first step in developing a baseline depot cost data base for installation services applicable to materiel distribution was to establish the kinds of

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[1] NAS's and MCASCP are not included in Major Force Program 7, Central Supply Management.

services to be charged. The Draft Uniform Cost Accounting and Production Reporting Manual for Depot Level Maintenance and Maintenance Support[1] was used to gain insight into the types of installation level services considered appropriate for charging to mission activities. Although geared to depot maintenance, the list of common services devised for future allocation provided a point of departure for the study group to use in identifying the types of services. The limiting factor in adapting the draft manual's allocation guidance to DODMDS study group use was that the level of detail required to support the proposed allocation procedures was neither currently nor readily available; this was so because the section on base operations/station support included in the manual represented a proposed disposition of support costs, not current Service practice[2]. Given the time constraint under which the study group was operating, it was clear that a less detailed means of allocating cost of installation level services had to be used.

b. The second step was to examine Army Industrial Fund (AIF) regulations for the current handling of installation services charged to mission activities. Both depot maintenance and distribution mission activities currently operate under industrial fund cost reporting procedures which require the allocation of installation level services to mission activities. AIF regulation AR 37-55[3] provided another reference point for distinguishing between installation services to be charged to mission activities and those which

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[1]Uniform Cost Accounting and Production Reporting Manual for Depot Level Maintenance and Maintenance Support (draft) prepared by the Joint AMC/NMC/AFLC/AFSC Commanders' Panel for Development of a Joint Depot Maintenance Cost Accounting Manual in response to LSPC Task Order 1-73.

[2]Ibid, p. 4-53 to 4-63, paragraph 4.2.1.E.4, Base Operations/Station Support.

[3]AR 37-55, 1 July 1972, Uniform Depot Maintenance Cost Accounting and Production Reporting System, updated 25 Sept 75.

should not. Using AR 37-55, in conjunction with discussions with representatives of the other Services and DLA, produced the following four types of services to be charged to distribution missons: facility services, management services, local transportation services, and automated data processing services. The DODMDS study group components of each type are described below:

(1) Facility Services

(a) Maintenance and Repair (M&R) of Real Property includes expenses incurred by building trades shops, construction units, grounds and pavements units, machine shops, real property management, engineering and administrative offices.

(b) Utilities includes expenses to procure or produce and distribute all utilities except communications, i.e., electricity, water, steam, compressed air, gas, and sewage; expenses to operate air conditioning and heating plants.

(c) Minor Construction includes expenses to erect, install, or assemble a new real property facility. Expenses to add, alter, convert or replace existing real property, in FY 1975 and not to exceed $50,000 of Operations & Maintenance (O&M) funds per project.

(d) Other Engineering Support includes expenses for fire protection, custodial services, entomology and pest control, refuse collection and disposal, snow removal, and facilities engineering.

(2) Management Services

(a) Command & Staff including administrative services, legal office, Inspector General, plans and analysis, safety, and (depending on the Service/Agency) manpower requirements, management engineering, production planning and work measurement.

(b) Comptroller including payroll, financial inventory accounting, cost accounting, appropriation accounting, general accounting, and budgeting.

(c) Personnel including support of both civilian and military personnel.

(d) Communications including maintenance and repair and administration of the installation telephone network, autovon, local and toll charges, and local telegraph/telex charges.

(e) Security including perimeter and gate security, vehicle registration, and traffic control.

(f) Printing and Duplication.

(g) Equipment Management.

(3) Local Transportation: cost to operate and maintain a fleet of vehicles.

(4) Automated Data Processing (ADP): cost to operate and maintain an installation computer center.

c. Installation functions which were not regarded as supporting distribution missions include troop/fleet support functions such as military bands, chaplain, service clubs, recreational/hobby activities, military exchanges and commissaries, employee recreation associations, military medical and dental activities, etc.

d. Table 2-2, page 2.12, shows the list of installation services and the corresponding Service/DLA accounts where the support costs are recorded. It can be readily seen that the problems of differing accounting systems and organizational structures encountered in devising SDO costs for distribution functions are also present in the area of installation services.

e. The list of installation services was incorporated into the DODMDS Data Call, RCS: DD-I&L (OT) 763, in the form of letters to HQ AFLC, HQ DLA, HQ NAVSUP, the five air stations, and the two MCLSB's. Included in the data call were suggested allocation techniques related to the four basic types of service. For facility services the study group

Table 2-2. Account Codes For Installation Services

	Army[1]	Navy/USMC[3]	Air Force	DLA[7]
Facility				
Maintenance & Repair	K	M	50000[4] 60000[4]	931,934 938,939
Utilities	J	N	20000[4]	935
Minor Construction	L	R	73000[4]	936
Other Eng. Support	M	P	10000[4] 40000[4]	937
Management				
Command & Staff	N,A	D1-1A00 D1-1B00 D1-1C00 D1-1D00 D1-1E00	2010XX[5] 2014XX[5] 3010XX[5] 3011XX[5] 3710XX[5] 3515XX[5] 3616XX[5]	910 920 (exc 929) 952
Communications	No charges[2]	LA-6XXX L1-6XXX	3010XX[5]	970
Security	G	L1-6B00	3043XX[5]	953,954
Printing & Repro.	N	D1-1J00	3011XX[5]	951
Equipment	B	D1-1R8X	from 1.9 acct.[6]	940 (exc 942)
Base Transportation	D	L7-6XXX	3242XX[5]	929,942
ADP	P	DP-1H00 DP-2999	3515XX[5]	960

(See footnotes on next page)

[1] Account code source: AR 37-100-75, Army Management Structure, Section XII, Base Operations - Z Accounts, effective 1 July 1974.

[2] In FY 75, Army Communications Command (ACCOM) Detachments at DARCOM depots did not bill the depots for services provided. Autodin and long lines charges were charged to P39 funds. The result was that there were no communications charges included in the Base Operations expenses charged to supply or maintenance missions.

[3] Account code source: NAVCOMPT Manual, Volume II, Chapter 4, Part D.

[4] Account code source: AFM 300-4, Volume IV (C-1), Civil Engineering Cost Account, 15 March 1974.

[5] Account code source: AFR 170-5, Responsibility Center/Cost Center Codes, 20 May 1969 (C11).

[6] Costs for Equipment Management at ALCs were charged to DODI 7220.17 account code 1.9, Overall Depot Support. Because this is an installation level function, costs were migrated out of supply support and into supply overhead.

[7] DLAM 7000.1, Section XXIV, O&M Account Codes, 20 May 1975.

recommended allocating on the basis of the ratio of distribution-utilized covered square feet to total installation covered square feet. For management services, the ratio of distribution population to total installation population was recommended. For base transportation, the study group recommended using the ratio of distribution assigned vehicles to total number of vehicles. Finally for ADP services AFLC, NAS's, MCASCP, and MCLSB's were advised to allocate ADP on the basis of the ratio of machine hours used to support distribution to total installation machine hours. The study group did not request DLA or NAVSUP to allocate ADP since both headquarters had previously established accounts for reporting ADP charges in support of their distribution missions. Other exceptions incorporated into the initial request for the allocation of installation services involved Navy activities receiving services from outside the installation organization. In the case of the NAS Norfolk which receives fire protection at no cost from Naval Base Norfolk and for NSC Pearl Harbor which receives civilian personnel service at no cost from a centralized personnel office, estimates of the applicable costs associated with providing the services were requested.

5. Army Cost Reporting

Army depots were not asked to allocate costs of installation services in support of materiel distribution because costs for Army depots already reflect the allocation of installation services. For the 11 Army depots, therefore, the problem was to segregate costs of installation services from reported distribution costs. In order to segregate these costs, the components had to be understood. What follows is a brief description of the cost reporting for Army distribution activities and how installation services costs were segregated.

a. The DODMDS data source for Army depot costs is the Depot Operations Cost and Performance Report, designated in FY 75 as RCS AMCSU-238, hereinafter referred to as the 238 report. The data in the 238 report is presented by Army Management Structure (AMS) codes from that portion of AR 37-100-75 which implements the DODI 7220.17 account codes for SDO.

Because Army SDO's operate under Army Industrial Fund procedures, the cost data reported against individual functional account codes is built up from a productive labor rate and three overhead rates:

(1) Average labor rates are established for productive civilian labor, include factors for leave and fringe benefits, and are calculated at a locally determined organizational level, i.e., branch, division, or directorate.

(2) In-shop overhead rates are established for supervisory and clerical effort determined for the same organizational level as average labor rates.

(3) Above-shop overhead is the rate set at the directorate level which covers overall support costs within the directorate and costs of installation services charged to SDO.

(4) General Administrative Expense (GAE) is a single installation level overhead rate which recoups the costs of installation services which cannot be identified to specific projects or missions.

b. One effect on cost reporting due to the AIF procedures is the treatment of the AMS codes for support, training, and stock control. Costs in these AMS codes are entered as memo entries in the 238 report since they are included in the in-shop and above-shop overhead rates charged to functional accounts as indirect expense.

c. Another effect on cost reporting due to AIF procedures is the application of installation services costs to individual functional accounts by way of the above-shop and GAE overhead rates. Costs of installation services in Army parlance are referred to as Base Operations Expenses (BOE) from the "Z" accounts described in AR 37-100-75, Section XII. BOE are incurred in O&MA PE 722896 in providing services to mission activities. Some BOE were directly funded by DESCOM (formerly USAMIDA) and not charged to mission activities in FY 75. The Army Food Program and personnel support are examples of BOE which were not distributed to missions in accordance with AR 37-55 policy.

d. Distributable costs incurred in PE 722896 were BOE which were charged to PE 721111, SDO, in one of the following ways:

(1) Directly identified to the distribution mission, as in maintenance and repair of distribution warehouses or direct ADP support.

(2) Allocated as indirect expense based on some ratio; for example, population for other engineering support or vehicles assigned for vehicle operations and maintenance.

(3) Distributed as General Administrative Expense on the basis of mission manhours, as in the case of fire protection or administrative services.

e. BOE distributed to distribution according to paragraphs 5.d.(1) and 5.d.(2) above are costed as part of the above-shop overhead rate and appear in the 238 report as part of the indirect cost (column K2) applied to each functional account. The remainder of indirect costs are composed of support, training and stock control costs shown as memo entries in the 238 report. BOE distributed to distribution according to paragraph 15.d.(3) are costed at the installation GAE rate and appear in the 238 report as GAE cost (column K1) applied to each functional account. Table 2-3, page 2.17, summarizes the AIF procedural impact on reported costs by indicating the program element in which costs are incurred, the functions for which they are incurred, of what they are composed, the AIF rate which incorporates them, and finally, where they appear in the 238 report.

f. Finally in order to segregate BOE from materiel distribution costs, the indirect expenses were totalled from applicable functional accounts, i.e. those not excluded according to paragraph B.3.d. above. Memo accounts relate. to other supplies (non-ammo) workload were summed and then subtracted from total indirect expenses. Net indirect expenses plus GAE charged to applicable accounts equal total BOE charged to the DODMDS-derived distribution mission for each Army depot.

Costs Incurred To	Are in	Are for	Are composed of	Are included in	And appear in the 238 report as
A. Perform DODI 7220.17 functions	PE 721111	Receiving, packing, bulk issue, shipping, COSTS, etc.	Productive civilian labor with factor for leave and fringe	Average labor rate	Civilian labor cost in column I
			Direct material and supplies		Direct material & supplies in Column J
			Other direct O&M		Other direct O&M in Column K
B. Support DODI 7220.17 functions	PE 721111	Support, Training, Stock Control	Indirect civilian labor, indirect material and supplies, all other O&M	In-Shop overhead rate	Indirect cost in Column K2
				Above-shop overhead rate	Indirect cost in Column K2
C. Support DODI 7220.17 functions	PE 722896	Base Operations Expense - Z Accounts	Installation support as established in AR 37-100-75 which are distributable according to Table 1-1 in AR 37-55	Above-shop overhead rate	Indirect cost in Column K2
				General & Administrative Expense (GAE) rate	GAE cost in Column K1

Table 2-3. Army Industrial Fund (AIF)

g. The result of applying the above procedure to 238 report costs is the stratification of Army distribution costs into DODMDS categories of handling, storage, supply support and supply overhead. Supply overhead is composed of installation services charged to the materiel distribution mission at each of the 34 activities. DARCOM was requested to provide a breakdown of the supply overhead costs by AMS code.

6. Final Allocation Procedures

a. Having derived installation services costs for each of the Army depots according to the above procedure, an indepth investigation of a single Army depot's locally devised allocation procedures was undertaken to ascertain the specific procedures used to obtain the installation services costs reported in the 238 report. This was necessary since DARCOM promulgates only general guidelines for charging installation services to mission activities.[1] The Army depot selected was Anniston (ANAD) based upon the recommendation of DARCOM comptroller personnel. DODMDS study group interaction with personnel from ANAD, in addition to personnel from HQ DLA and NAS's indicated that the allocation method recommended by the DODMDS Data Call for Utility and Other Engineering Support costs should be changed to a population rather than square foot ratio. Using ANAD as a benchmark, the ratio used to allocate utility costs to missions at ANAD closely approximated the ratio used to allocate all installation services prorated on a population basis. In fact, at ANAD all of the installation services costs not directly identified to a mission, e.g., maintenance and repair projects, were allocated on either a population (indirect) or mission manhours (G&E) basis with the exceptions of transportation and ADP. ANAD procedures established a basis for subsequent sensitivity analysis discussed in paragraph B.9.

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[1] AMCR 37-5, 10 October 1973, Accounting and Distribution of Base Operations Costs.

b. The Army cost reporting procedure of charging indirect expense and GAE to individual functional accounts on a rate basis permits the identification of those installation services costs applicable only to DODMDS selected distribution accounts. The ability of the Army accounting system to distinguish between installation services costs related to an excluded function and those applicable to distribution functions, pointed out the need for a similar ability within the other Service and DLA systems. Revised DODMDS guidance for the activities performing allocations requested that personnel, buildings, vehicles and ADP machine hours associated with the excluded functions contained in Exhibit 2-1, page 2.62, be subtracted from distribution organization totals in order to calculate resources related to materiel distribution. The net values were then to be used by respondents in deriving allocation ratios.

c. This change in the derivation of ratios coupled with the switch of two elements of facility services from a square foot to a population basis produced the final set of DODMDS guidelines for the allocation of installation services costs. They were as follows:

(1) Facility services.

(a) M&R - Actual or prorated on basis of distribution assigned covered square feet[1] to total installation covered square feet (supported with direct, i.e., non-reimbursable, resources where applicable).

(b) Utilities - Prorated on the ratio of distribution population[2] to total installation population (supported with direct resources where applicable).

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[1] Square feet assigned to distribution organization less square feet associated with, e.g., bulk fuel and water front facilities.

[2] Distribution organization total minus personnel related to excluded functions, e.g., manifested water cargo operations, installation equipment management, etc.

(c) Minor Construction - same as (a).

(d) Other Engineering Support - same as (b).

(2) Management Services - same as (b).

(3) Base transportation services - prorated on basis of number of vehicles assigned to distribution[1] to total installation vehicles.

(4) ADP - prorated on basis of machine hours in support of distribution[2] to total installation machine hours.

7. <u>Installation Services Costs</u>

The data as submitted by Army, Navy, Air Force, Marine Corps, and DLA activities are shown in detail under the heading "Reported Share" in Exhibit 2-3, pages 2.88 through 2.124, with the following adjustments made:

a. The distribution portion of the manpower requirements, production planning, management engineering, and work measurement costs performed by installation level organizations at NSC's and DLA depots/centers were merged into supply support costs in order to more closely match functions across Service/Agency lines. For ALC's, NAS's, and MCAS CP these functions are incorporated into overall depot support (1.9), one of the DODI 7220.17 prescribed accounts. Using ANAD as an example of the organizational structure at an Army depot these functions are split between the storage organization and an installation level organization. Consequently no migration of these costs was made for Army depots.

b. ALC's charge the costs related to maintaining

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[1] Less vehicles assigned to excluded functions, e.g., air cargo processing, water cargo processing.

[2] Less machine hours related to excluded functions, e.g., stock control, procurement operations, etc. DLA and NAVSUP ADP costs were independently estimated but with the proviso of excluding non-distribution costs for ADP.

materiels handling systems within the DODI 7220.17 account structure. As a result, the costs for this function appear as supply support costs. Since the work is performed by an installation level organization at other distribution activities, the costs of this function were transferred from supply support to supply overhead, specifically facility services.

8. Data Limitations

The results of the above procedures are summarized in Appendix C, Section 8, under the heading Supply Overhead. The data should be viewed within the context of the following limitations:

a. The data represent an estimate of the installation services costs incurred to support materiel distribution. They are an estimate of the potential savings associated with closure of the materiel distribution mission at an individual depot. The data represent a historical snapshot, that is, they represent conditions of population and storage/warehousing space and equipment for only FY 1975. The data can be used to project support costs under conditions which differ from the base year but the values themselves are FY 1975 depot specific.

b. Comparability problems abound due to accounting/organization differences which permeate the data bases from which the data were derived. Examples include:

(1) The disposition of local procurement costs differs by Service/Agency. In Army, AFLC, and DLA depot organization structures, local procurement is an installation service. At DLA centers local procurement is performed by the Inventory Control Point (ICP) for the collocated distribution activity. For Navy activities, procurement services are performed by part of the NAS Supply Department or NSC and were excluded from SDO costs. The local procurement costs expended in support of distribution missions were judged to be minor, therefore, costs were used as reported.

(2) Population ratios used differed by Service/Agency. Army depots prorate base operations expense on mission population. At ANAD the population involved in accomplishing installation services was not included in the calculation of distribution population as a percent of total. The DLA response to the request for allocation of installation services did not include the population involved in base operations functions in calculating population ratios for the DLA depots/centers. AFLC and Navy respondents employed total installation population in deriving population ratios used in allocations. Several Navy activities, however, receive installation services from organizational entities external to the NSC or NAS. This is the case where Public Works Centers provide facility services type support to all Navy customers in a geographic concentration. In FY 1975 this included the San Diego and Norfolk activities.

(3) Detailed scrutiny of the allocation schemes employed by the respondees pointed up the following anomalies: maintenance and repair costs associated with utility systems, grounds, pavements, railroad trackage, etc., had in some cases been allocated on a square foot basis, in some cases on a population basis, and for ALC's, not allocated to distribution at all. Also, for Navy activities, up to six different population ratios were used in computing costs for management, utility, and other engineering support services.

9. Sensitivity Analysis.

a. In order to determine the impact of the differences on model input data and, therefore, on modeling results, the DODMDS study group derived a standard allocation procedure to be imposed on each depot's total Operations & Maintenance costs for applicable installation services. The procedure was to employ a single population ratio representing the percent of distribution population to total installation population (including the population involved in providing installation services) in allocating management, utility and other engineering support services. This was in lieu of the schemes used by the Services and DLA in the DODMDS Data Call

submissions. Where the account structure permitted making a distinction between maintenance and repair costs related to utility systems, utility distribution systems, grounds, pavements and railroad trackage versus maintenance and repair on operational buildings, the former costs were allocated using the single population ratio used above. Where the distinction could not be made, the SDO share of maintenance and repair costs related to operational buildings was either used as reported or the portion identifiable to storage buildings (accounts vary by Service/Agency) was charged entirely to SDO. Base transportation and ADP costs were used as previously reported.

b. The data labelled "DODMDS Share" in Exhibit 2-3, page 2.88, are the results of applying the standard procedure to O&M totals for each of the 34 depots. Exceptions are as noted.

10. Summation.

a. Paragraphs B.4 through B.9 have shown the concurrent development of installation services costs for the Army, the other Services and DLA. For the Army, the problem was one of identifying and segregating these costs from reported data. For all others the problem was to estimate the distribution mission share of installation services expenses.

b. Both sets of allocated installation services cost data in Exhibit 2-3 were subjected to a wholesale/retail split of costs before being used as model input data. The procedure used to perform the split is described in Section E.

C. BASELINE DEPOT WORKLOAD

1. Introduction

Historical SDO cost must be coupled with the corresponding historical depot workload to become useful for model input and subsequent analysis. Since the focus of the DODMDS study is wholesale materiel

distribution, the model input data must be that data directly associated with the DOD wholesale distribution process. In actual practice supply depot workload with respect to the materiel distribution process encompasses more than the wholesale system being examined by the DODMDS study group. The distribution workload at all depots includes the processing of two types of stocks or materiel. First, wholesale level stock over which a DOD ICP has asset knowledge and exercises asset control to meet worldwide inventory management responsibilities. Second, retail level stock over which the depot receiving and storing the stock has asset knowledge and exercises asset control to satisfy requirements within the local area for local customers, collocated activities and/or tenant organizations. The depot cost data assembled by the DODMDS study group is applicable to both the wholesale and retail workload at Service operated depots. Therefore, it was necessary to construct a depot workload data base composed of both wholesale and retail processing actions for the Service operated depots. The depot cost data collected by the DODMDS study group for the DLA operated depots is applicable to only the wholesale materiel processing actions and hence no attempt was made to construct retail type workload for DLA depots.

2. Definitions and Measures

a. For DODMDS study group depot cost development purposes, historical depot workload was defined as annual outbound materiel shipments/transactions which were physically handled by a depot. Historical depot workload was measured by the following parameters; line items shipped (synonymous with line items issued), hundredweight shipped, cubic feet of shipments, and dollar value of shipments. In actual practice supply depot workload is a composite of a variety of other processes (such as receiving, physical inventory, preservation, rewarehousing, packing, etc.) and a multitude of parameters, such as inventory counts, packs, measurement tons received, etc. However, the assumption was made that outbound materiel movements, as measured in the four parameters, could be used as a surrogate for historical depot workload.

b. For depot cost development purposes the DODMDS depot workload was extracted from the DODMDS transaction data base. Depot workload was constructed on this basis rather than on the basis of Service/DLA accounting reports for two primary reasons; first, depot workload by DODMDS product was required for model input data development but depot workload as reported in the Service/DLA accounting system does not reflect outbound volume by NSN, FSC, FSG, or any other known standard product system. Second, the accounting reports were inconsistent in the parameters used to measure outbound activity, i.e., some reports used weight and line items shipped, some used cube (measurement tons) and line items shipped and some only reported line items shipped. In order to overcome the lack of product identity and uniformity in outbound activity measures in the accounting reports, the DODMDS study group depot workload data was constructed from the DODMDS transaction data base. Uniformity in the DODMDS study group depot workload was accomplished by applying a common catalog data base across all transactions. In this manner each NSN had the same weight, cube and price data applied across all transactions of that NSN regardless of the depot which issued the materiel. In this way, any parameter in the catalog data could be used as depot workload and that parameter measured consistently across all depots.

c. In order to develop depot workload data for depot cost, a special mechanical data file was created and dubbed Cost Mini File (CMF). This file contains an extract of all materiel issue/shipment transactions for each depot regardless of the customer. The CMF consists of eight data elements extracted from both the DODMDS wholesale and retail Mini-Shipment Files on a transaction by transaction basis. These data elements are the National Stock Number (NSN), DODMDS Product Number (See Book 4, Appendix D-2, Section 3), Shipping Depot Routing Identifier (RIC), Quantity (number of units of issue) Shipped, Unit of Issue Price, Unit of Issue Weight, Unit of Issue Cube, and a DODMDS Type Action Code (See Book 3, Appendix D-1, Section 2). The CMF is a depot workload file and includes only those shipments or materiel processing

actions, which were physically handled by the depot. Accountability transfers between wholesale and retail stock were excluded. For cost development purposes the wholesale and retail transactional information in this file was summarized to the DODMDS product level for each depot for both wholesale and retail stocks. Retail workload was not required for DLA depots.

3. Validation

a. To provide an independent check of the DODMDS study group extracted depot workload data base, the line items issued per depot in the CMF were compared to the line items issued per depot as reflected in the various Service/DLA generated accounting/management reports. Systemwide, the difference between the DODMDS study group depot workload data base and the accounting reports was less than five percent. The differences for individual depots, however, were considerably greater as reflected in Table 2-4, page 2.27. Some differences between the CMF and the Service/DLA accounting reports were expected, since different data bases were involved. In addition, the DODMDS Cost Mini-File for all Army depots was known to contain less than one year of retail shipment transactions.

b. An exact reconciliation on a shipment by shipment basis of the DODMDS and Service/DLA depot workload data was not possible due to the magnitude of the wholesale and retail data bases. However, the Service/DLA accounting reports provided a historical benchmark against which the CMF data could be compared. The rule of thumb used to evaluate the variance between the CMF data and accounting system data was 15 percent. Where the CMF data differed in line items shipped from the accounting report for an individual depot by more than 15 percent, a workload adjustment factor was applied. Army depot workload required the most extensive modifications since the Army retail data contained in the CMF was only for a few months of FY 76 rather than a full year of FY 75. Because of the variance in line items shipped between the DODMDS CMF and the Army accounting reports, the DODMDS study group depot workload data for each Army depot was adjusted to the number of line items shipped as shown in the Army management report (AMC 238). The

Table 2-4. Unreconciled DODMDS Depot Workload in [illegible]ne Items Shipped

Depot	Cost Mini File: Wholesale	Cost Mini File: Retail Not Adjusted	Cost Mini File: Total	SVC/DLA Mgmt Reports	% Difference
ANAD	93200	61112	154312	358771	- 132
CCAD	27762	86830	114592	231822	- 102
LEAD	371065	50461	421526	605027	- 44
LBAD	127759	27615	155374	238555	- 54
NCAD	572060	56752	628812	709846	- 13
PUAD	59896	18992	78888	140334	- 78
RRAD	454815	76023	530838	614724	- 16
SAAD	540177	32033	572210	834227	- 46
SHAD	195137	8243	203380	331664	- 63
TOAD	148888	3604[illegible]	184395	272390	- 47
TEAD	112730	22495	135225	219116	- 62
NASALA	306795	126869	433664	441652	- 2
NASJAX	224609	123135	347744	398270	- 15
NASNOR	275912	199721	475633	280681	+ 41
NASNI	362974	71542	434516	501142	- 15
NSCNOR	1560702	474984	2035686	2119326	- 4
NSCOAK	1367670	114749	1482419	1578083	- 6
NSCPH	86667	197197	283864	420224	- 48
NSCSD	212906	1077695	1290601	921084	[illegible] 29
MCASCP	235336	180210	415546	392467	+ 6
OCALC	942274	697825	1640099	1563845	+ 5
OOALC	588924	734694	1323618	1253074	+ 5
SMALC	464051	883357	1347408	1275855	+ 5
SAALC	868031	607209	1475240	1554702	- 5
WRALC	721000	749717	1470717	1541338	- 5
MCLSBLANT*	112853	218351	331204	NA	NC
MCLSBPAC*	201767	56225	257992	NA	NC
DCS[illegible]	2163349	-	2163349	2352091	- 9
DDM[illegible]	1874116	-	1874116	1685431	+ 10
DDM[illegible]	3118436	-	3118436	3256073	- 4
DD[illegible]U	3769224	-	3769224	4002569	- [illegible]
DD[illegible]C	1322211	-	1322211	1307824	+ [illegible]
DESC	2440693	-	2440693	2602392	- [illegible]
DGSC	1134435	-	1134435	1133685	+ .1
TOTAL	27058424	6990056	34048480	35096988	- 4.7

*See Paragraph C.3.e.

CMF data for the non-Army depots were used without modification except at four Navy depots: NAS Norfolk, NAS North Island, NSC Pearl Harbor and NSC San Diego. At these four depots the line items shipped workload in the CMF differed from the management reports (NAVSUP PUB 295) by more than 15 percent. The DODMDS study group depot workload modification procedure for these Navy depots adjusted the total number of line items shipped for these depots to within plus or minus 10 percent of the management report line items shipped by depot.

c. Procedurally, the DODMDS study group retail depot workload was adjusted for those individual Army and Navy depots as follows:

(1) For each depot, subtract the number of wholesale line items shipped (as reflected in the CMF) from the total line items shipped recorded in the accounting reports. The balance is the computed annual retail line items shipped.

(2) Determine the ratio of the computed annual retail line items shipped to the CMF retail line items shipped . This produced a depot workload adjustment factor which was applied to the number of retail line items shipped in the CMF. A factor of 1.0 indicated that the magnitude of computed retail line items shipped was the same as the CMF retail line items shipped. A factor greater than 1.0 indicated that CMF retail line items shipped had to be increased to approximate the computed retail line items shipped as derived from the accounting reports. A factor less than 1.0 indicated that the DODMDS retail line items shipped had to be decreased to approximate the computed retail line items shipped as derived from the accounting reports.

(3) The depot workload adjustment factor was then applied to the CMF retail line items shipped to create the adjusted CMF retail line items shipped .

(4) The adjusted CMF retail line items shipped were summed with the CMF wholesale line items shipped to derive the CMF baseline line items shipped for each depot.

(5) The depot workload adjustment factor was subsequently applied to the other depot workload parameters of weight, cube, and price as reflected in the Retail CMF, to develop the adjusted CMF Retail Workload Report. The adjusted CMF retail workload was summed with the CMF wholesale workload for each workload parameter to derive the DODMDS baseline workload in each parameter.

d. The use of line items shipped, as reflected in the accounting/management reports, as the controlling data element for reconciliation of the CMF workload was considered appropriate since line items shipped in the accounting/management reports were the most reliable and consistent depot workload parameter across all 34 depots. In addition, line items shipped as a measure of depot workload is not subject to Service/DLA maintained catalog data bases which are used to calculate the weight and cube data appearing in the accounting reports. The adjustment procedure above was made under the assumption that the wholesale portion of the DODMDS CMF data were essentially correct.

e. The number of line items shipped reported in the management reports available to the DODMDS study group for the MCLSBLANT and MCLSBPAC did not appear to reflect the DODMDS study group extracted depot workloads and were not considered. Thus, no modifications of the DODMDS file numbers were made for the two Marine Corps depots.

f. Table 2-5, page 2.30, displays for each depot the depot workload adjustment factors (Col. 4), the adjusted DODMDS retail workload (Col. 5), the total DODMDS workload in line items shipped (Col. 6) and the variation in total (Col. 8) and percentage (Col. 9), between the DODMDS study group total depot workload and the accounting/management report depot workload. On a systemwide basis the difference between the depot workload data bases is less than two percent. Using adjusted data, the DODMDS study group depot workload for every depot was brought within 15 percent of the line items shipped workload in the accounting management report.

Table 2-5. DODMDS Depot Workload Reconciliation in Line Items Shipped

Depot	Cost Mini File Wholesale	Cost Mini File Retail Not Adjusted	Factor	Adjusted DODMDS Retail	Total DODMDS Workload (2)+(5)	SVC/DLA Mgt Rpts	Difference (6)-(7)	% Difference
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ANAD	93200	61112	4.32	264004	357204*	358771	- 1567*	- .44
CCAD	27762	86830	2.33	202314	230076*	231822	- 1746*	- .76
LEAD	371065	50461	4.50	227075	598140*	605027	- 6887*	- 1.15
LBAD	127759	27615	4.01	110736	238495*	238555	- 60*	- .03
NCAD	572060	56752	2.38	135069	707129*	709846	- 2717*	- .38
PUAD	59896	18992	4.16	79008	138904*	140334	- 1430*	- 1.03
RRAD	454815	76023	2.07	157367	612182*	614724	- 2542*	- .42
SAAD	540177	32033	9.12	292138	832315*	834227	- 1912*	- .24
SHAD	195137	8243	16.45	135597	330734*	331664	- 930*	- .28
TOAD	148888	36047	3.38	121839	270727*	272390	- 1663*	- .61
TEAD	112730	22495	4.75	106853	219583*	219116	+ 467*	+ .21
NASALA	306795	126869	1.00	126869	433664	441652	- 7908	- 1.84
NASJAX	224609	123135	1.00	123135	347744	398270	- 50526	-14.53
NASNOR	275912	199721	.14	27961	303873	280681	+ 23192	+ 7.63
NASNI	362974	71542	1.28	91574	454548	501142	- 46594	-10.25
NSCNOR	1560702	474984	1.00	474984	2035686	2119326	- 83640	- 4.11
NSCOAK	1367670	114749	1.00	114749	1482419	1578083	- 95664	- 6.45
NSCPH	86667	197197	1.47	289879	376546	420224	- 43678	-11.60
NSCSD	212906	1077695	.77	829825	1042731	921084	+121647	+11.67
MCASCP	235336	180210	1.00	180210	415546	392467	+ 23079	+ 5.55
OCALC	942274	697825	1.00	697825	1640099	1563845	+ 76254	+ 4.65
OOALC	588924	734694	1.00	734694	1323618	1253074	+ 70544	+ 5.33
SMALC	464051	883357	1.00	883357	1347408	1275855	+ 71553	+ 5.31
SAALC	868031	607209	1.00	607209	1475240	1554702	- 79462	- 5.39
WRALC	721000	749717	1.00	749717	1470717	1541338	- 70621	- 4.80
MCLSBLANT	112853	218351	1.00	218351	331204	NA	-	-
MCLSBPAC	201767	56225	1.00	56225	257992	NA	-	-
DCSC	2163349	-	-	-	2163349	2352091	-188742	- 8.72
DDMP	1874116	-	-	-	1874116	1685431	+188685	+10.07
DDMT	3118436	-	-	-	3118436	3256073	-137637	- 4.41
DDOU	3769224	-	-	-	3769224	4002569	-233345	- 6.19
DDTC	1322211	-	-	-	1322211	1307824	+ 14387	+ 1.09
DESC	2440693	-	-	-	2440693	2602392	-161699	- 6.63
DGSC	1134435	-	-	-	1134435	1133685	+ 750	+ .07
TOTAL	27058424	-	-	8038564	35096988	-	-630492	- 1.80

*Column (6) was intended to equal column (7). The difference is due to minor data corrections introduced after the annual retail values had been constructed.

4. Optimization Model Baseline Workload Vs Cost Mini-File

a. The DODMDS customer demand file (Mini-Shipment III), which is used as a basic input to the optimization model, and Cost Mini-File differ in magnitude and content. The basic reason for these differences is that different types of transactions were included/excluded from the two files. The Mini-Shipment III is a customer demand file and includes only those transactions which were considered as customer demands on the wholesale system. The Cost Mini-File is a historical depot workload file used for depot cost computations and includes all accountable shipments/transactions which were physically handled by each depot. The primary differences between these two DODMDS study group data files are:

(1) Computer system ownership transfers (DODMDS study group type action code 4, see Appendix D-1) are included in the customer demand file but excluded from the CMF.

(2) Redistributions between depots and disposal actions are excluded from the customer demand file but included in the Cost Mini-File.

(3) Retail shipments are excluded from customer demand file but included in the Cost Mini-File for Service operated depots.

5. Historical Depot Workload

a. The DODMDS historical depot workload, with adjustments, is displayed in Table 2-6, page 2.32. Table 2-6 reflects, for Service operated depots, the sum of wholesale and retail outbound movements measured in weight, cubic feet, shipments and value. For DLA operated depots Table 2-6 reflects only wholesale outbound movements. The depot workload data reflected in Table 2-6 was used, in conjunction with the historical depot cost data as described in Paragraph B, in the transformation process described in Paragraph D, to develop depot variable cost per hundredweight per DODMDS product as input data to the optimization model.

Table 2-6. DODMDS Historical Depot Workload Summary by Depot

	Weight-CWT	Cubic Feet	Line Item Shipments	Value-$000
ANAD	2594925	11108268	357204	853453
CCAD	227418	5083516	230076	713391
LEAD	1962637	10106699	598140	827263
LBAD	399132	7604003	238495	192310
NCAD	2085518	14788683	707129	760081
PUAD	491803	3941014	138904	409349
RRAD	2592403	27327366	612182	711912
SAAD	805836	5649728	832315	350311
SHAD	1445291	11470502	330734	333187
TOAD	627198	5760595	270727	339409
TEAD	1610051	10228349	219583	600978
NASALA	160668	3776725	433664	617513
NASJAX	180986	4993136	347744	465735
NASNOR	189699	3351175	303873	779062
NASNI	470745	8919495	454548	733572
NSCNOR	2070480	9050432	2035686	386276
NSCOAK	1626480	8937508	1482419	386988
NSCPH	482312	2700068	376546	47906
NSCSD	907212	6459075	1042731	199425
MCASCP	164926	3071779	415546	376973
OCALC	1107938	10688690	1640099	4772678
OOALC	589374	6809646	1323618	1488734
SMALC	727371	7328298	1347408	2253103
SAALC	1394733	10794669	1475240	3679962
WRALC	809101	7981544	1470717	2737314
MCLSBLANT	521119	3873988	331204	482151
MCLSBPAC	941466	7686958	257992	838493
DCSC	633883	3616892	2163349	237579
DDMP	5123576	21655849	1874116	562846
DDMT	3178641	14758461	3118436	483820
DDOU	904889	6614065	3769224	319067
DDTC	3385651	13084621	1322211	329440
DESC	78939	635170	2440693	273168
DGSC	1769253	8711978	1134435	241530
TOTAL	42261654	273568962	35096988	28579978

D. TRANSFORMATION PROCESS

In principle, the depot cost on a per unit of workload basis can be based either on engineering estimates or on historical experience. The engineering estimate approach of developing depot cost per unit of workload was rejected by the study group because of the time and resource requirements. However, a bottoms-up engineering-type approach for estimating the depot cost associated with the conceptual depot and for modernization of existing depot handling and storage operations was used in the DODMDS effort, see Section 3 of this Appendix. The use of historical experience as a basis for depot cost requires the formulation of a parametric (or statistical) framework. The parametric approach to depot costing has the advantage of being manageable and producing depot cost estimates which provide insights into future cost of the DODMDS and system interactions. The disadvantage of the parametric approach is that it does not provide exact costs despite the appearance of scientific precision.

1. Objective

a. The objective of the DODMDS study group analytical framework relative to historical depot cost and workload is to provide a logical and structured methodology which converts real world depot cost data into data which can be used for analytical purposes. Historical depot cost, in the real world, is collected and reported by the various accounting system structures in terms of dollars by functional area within the depot. For DODMDS study group analyses the functionally oriented historical depot cost data had to be transformed into depot cost per hundredweight for each DODMDS commodity.

b. The conversion of real world depot cost data (dollars by functional area) into data in the form of cost per hundredweight per commodity was motivated by:

(1) The input data requirement of the DODMDS optimization model, i.e., depot variable cost must be in the form specified by the model (dollars per hundredweight per commodity).

(2) The conviction that on a cost per hundredweight basis DODMDS commodities do not contribute equally to depot cost.

(3) The overall objective of the DODMDS study of evaluating various supply depot missions, in terms of depot - commodity combinations, which may differ from history. This requires that depot variable cost be developed for every depot-commodity combination regardless of a given depot's historical experience with a given commodity.

(4) The need to predict depot variable cost, by depot and systemwide, which would result from a variation in commodity mix and/or volume.

2. Two Problems

Two basic problems had to be solved to parametrically develop depot cost input data for the optimization model: (a) historical depot cost data had to be categorized into fixed and variable components and (b) a mathematical procedure to transform depot cost by function into cost per hundredweight of each DODMDS commodity had to be derived.

3. Fixed Versus Variable Depot Costs

In principle, all depot costs are fixed in the short run and variable in the long run. In the annual time frame with which the DODMDS study group was dealing, a clear distinction between fixed and variable depot costs was necessarily, to a degree, judgmental.

a. The DODMDS study group depot variable costs stem from an extensive validation and scrubbing of accounting system distribution costs to determine those functionally oriented cost components which were related to materiel distribution workload. The scrubbed accounting system data discussed in Paragraph B of this section represent historical Service and DLA decisions on personnel staffing to accomplish the distribution workload at each of the depots. Distribution workload in the depot is composed of commodities flowing through a warehouse and/or processing space. Hence, the DODMDS study group depot

variable costs are those cost elements which can be attributed to materiel distribution workload or commodity flows.

b. The organizations which perform the materiel distribution mission under study were all part of larger organizational entities at their geographical location. The distribution organization receives elements of support necessary to accomplish the distribution mission from these installation level organizations. The elements of support are the facility, management, ADP, and base transportation services discussed in Part B. These installation support elements are required for the accomplishment of any logistics or operational mission within DOD. The magnitude of costs for individual distribution missions associated with these support elements is dependent on the relative size of the distribution mission vis-a-vis the total installation. Installation support costs applicable to distribution are categorized as fixed costs for model analysis, since they represent the DODMDS structural cost associated with performing the materiel distribution mission at 34 locations and the potential savings associated with closure of the distribution mission at a given location. Therefore, for DODMDS study purposes, depot fixed costs were composed of the estimated costs of providing common installation services support to distribution missions. The study group recognized that DODMDS-derived depot fixed costs were valid only within a finite range around historical distribution workload volume and become variable to a degree outside that finite range, i.e., in actuality a supply depot cannot expect to incur the same level of historical fixed cost at half or twice the historical volume of throughput. In order to project fixed costs at depots where the historical volume of throughput radically changed, a standard fixed cost curve was devised. It is described in Paragraph E.

4. Measures of Workload

The DODMDS historical baseline depot variable costs described in Paragraph B produced a set of DOD wide depot costs (shown in Appendix C, Section 7 and Table 2-7, page 2.36) which are comparable from the

Table 2-7. Depot Variable Cost in DODMDS Base Year (Dollars in Thousands)

	Supply Handling Cost	Supply Storage Cost	Supply Support Cost	Total Variable Cost
1 ANAD	3,594	4,771	2,818	11,183
2 CCAD	1,830	955	1,090	3,875
3 LEAD	5,010	4,091	2,939	12,040
4 LBAD	3,378	2,664	1,544	7,586
5 NCAD	6,781	2,535	3,386	12,702
6 PUAD	2,112	1,386	721	4,219
7 RRAD	7,373	5,647	4,676	17,696
8 SAAD	7,466	2,869	3,243	13,578
9 SHAD	4,685	2,352	2,310	9,347
10 TOAD	3,436	2,960	1,398	7,794
11 TEAD	5,312	3,568	2,025	10,905
12 NASALA	3,315	1,318	1,800	6,433
13 NASJAX	2,299	876	1,092	4,267
14 NASNOR	2,091	726	1,072	3,889
15 NASNI	2,649	1,492	1,943	6,084
16 NSCNOR	10,566	1,597	4,795	16,958
17 NSCOAK	8,379	1,391	4,688	14,458
18 NSCPH	1,776	431	853	3,060
19 NSCSD	3,095	578	1,097	4,770
20 MCASCP	1,736	841	1,210	3,787
21 OCALC	9,702	3,798	8,557	22,057
22 OOALC	6,883	3,307	8,048	18,238
23 SMALC	6,434	3,548	8,409	18,391
24 SAALC	12,195	3,446	9,713	25,354
25 WRALC	9,503	3,755	9,348	22,606
26 MCLSBLANT*	1,930	3,158	1,675	6,763
27 MCLSBPAC*	2,456	6,561	3,649	12,666
28 DCSC	8,800	2,652	3,141	14,593
29 DDMP	10,177	2,142	3,414	15,733
30 DDMT	13,820	3,160	3,362	20,342
31 DDOU	13,687	3,790	2,639	20,116
32 DDTC	11,162	3,069	3,128	17,359
33 DESC	6,016	1,276	1,739	9,031
34 DGSC	7,481	1,353	2,069	10,903
TOTAL	207,129	88,063	113,591	408,783

*These MC costs were for the development of standard depot variable cost. They differ from the revised costs provided in September 1977 and shown in Table 3.11, page 123, (Reference: HQ USMC letter LMP/DEB/sp 5000 dated 29 September 1977, subject: Comments on DODMDS Chapters 1, 2 and 3 and DODMDS study group letter dated 5 October 1977, same subject). The impact of the difference between the two sets of costs on the standard depot variable cost was insignificant and the corrected costs were not used for this purpose.

standpoint that these cost data represent labor and supplies expenditures for the same type of effort for all depots. These costs, however, are not meaningful until seen in relationship to depot workload. Workload at individual DODMDS depots varied widely in that some depots were line item oriented with little weight, while other depots were weight oriented with relatively few line items. Using any single measure of workload, such as line items or hundredweight, produces a wide range of costs per unit across the 34 DODMDS depots. Table 2-8 illustrates the variation in unit costs across all 34 depots when single measures of depot workload are used.

Table 2-8

Historical Depot Cost Per Unit of Workload - Number of DODMDS Depots In Each Cell

		$/CWT				
		0-10	10-15	15-20	20-25	25 +
	0-10	5				3
$/LIS	10-15	2	1			2
	15-20		1		3	6
	20-25	2				
	25 +	4	3	1	1	

Table 2-9, page 2.38, shows that when all 34 depots are ranked from lowest to highest in terms of variable cost per unit of materiel issued, very few depots exhibit a stable ranking in all three measures of depot throughput. These variable costs per unit of workload differences as reflected in Table 2-8 are rooted in the differing commodity mixes which were processed by the individual depots in the base year. A comparison of unit cost developed by a single measure of depot workload across all depots is not meaningful. Because of this variation in the composition of depot workload in the DODMDS, the study group recognized the need to relate depot variable cost to more than one measure of depot workload in order to develop meaningful cost per hundredweight of each DODMDS commodity which could be used for model evaluation. For DODMDS purposes outbound materiel

Table 2-9. Ranks in Terms of Variable Cost/Unit of Output

	Output Measure		
	LIS	CWT	Value
DESC	1	34	29
NSC SD	2	4	20
DDOU	3	26	31
DDMT	4	10	32
DCSC	5	28	34
NSCPH	6	9	33
NSCNOR	7	14	27
DDMP	8	1	22
MCASCP	9	27	9
DGSC	10	8	28
NSCOAK	11	15	24
NASJAX	12	29	8
NASNOR	13	25	2
DDTC	14	3	30
NASNI	15	17	7
OCALC	16	24	1
SMALC	17	30	5
OOALC	18	32	12
NASALA	19	32	11
WRALC	20	31	6
SAAD	21	20	25
CCAD	22	21	3
SAALC	23	22	4
NCAD	24	6	17
LEAD	25	7	15
MCLSBLANT	26	18	14
SHAD	27	11	23
TOAD	28	16	19
RRAD	29	13	21
PUAD	30	5	10
ANAD	31	2	13
LBAD	32	23	26
MCLSBPAC	33	19	16
TEAD	34	12	18

movements were considered to be an accurate and manageable surrogate for depot workload (it was fully recognized that in actuality depot workload is composed of many measures in addition to outbound materiel movements). Table 2-6, page 2.32, presented the summary of the outbound materiel movements measured in CWT, cubic feet, lines and dollar value which represent the workload (or throughput) of each DODMDS depot in the base year.

5. Concept of Difficulty Factors

a. The transformation of depot historical variable cost by function into depot variable cost per hundredweight of each commodity was accomplished by a concept titled Difficulty Factors. A Difficulty Factor is simply a standard depot variable cost per hundredweight (CWT) for each of the 69 DODMDS commodities. The underlying assumption for Difficulty Factors is that the depot variable cost required to process a CWT of one commodity is not equal to the depot cost to process a CWT of another commodity. Additionally, it is assumed that the differences in depot cost depend on the collective characteristics of the commodity mix at individual depots. The Difficulty Factor concept is based on a mathematical relationship between various measures of depot workload and historical depot cost.

b. For analysis purposes, depot workload as reflected by the outbound materiel movements was measured in three parameters; line items shipped, cubic feet of the shipments, and dollar value of the shipments. The causal relationship between these parametric measures of depot workload and depot cost stems from the fact that two of the parameters are commodity related while one of the parameters (line items shipped) is common to all commodities. The parameter of line items shipped represents documents (picking orders) which are sent to a warehouse for pick, pack and materiel movement. Each piece of paper requires distribution resources to be expended and thus the more pieces of paper sent to a warehouse the greater the cost of operations. The parameter cubic feet of materiel shipped represents the total volume

of materiel shipped over a period of time. Volume of materiel shipped is, to a degree, dependent on the types of commodities flowing through a depot in the base year. Two depots with an equal number of line items shipped but with significantly different volumes of materiel shipped will have different depot cost characteristics. In the same view, on a micro-level, a given depot processing a hundredweight of feathers will incur a greater cost than if processing a hundredweight of canned gooas. The parameter of value of materiel shipped is related to depot variable cost in that internal distribution management functions have been regarded as commodity related and the higher the value of materiel shipped the more internal management type cost incurred by a depot. The bulk of high value commodities are the reparables. The presence of reparable commodities (reflected in the high value of materiel shipped) in the workload of individual distribution missions produces more extensive inspection and management systems than at distribution missions having no reparable commodities (reflected in low value of materiel shipped). These systems are necessary to control the interface between distribution and on-base depot level maintenance in the processing of reparables. Two depots whose respective workloads are similar in line items shipped and volume of materiel shipped but differ in the relative mix of reparables to consumables will exhibit different depot cost characteristics, i.e., a depot processing a hundredweight of jet engines will incur a greater cost than if processing a hundredweight of nails. The Difficulty Factor concept mathematically establishes the relationship between these three parametric measures of depot workload and depot variable costs.

6. <u>Depot Cost Regression</u>

a. The mathematical relationship between depot throughput characteristics and depot variable cost was developed by using the annual value for each of the 34 DODMDS depots as a data point. These points are the only existing data nodes which relate the throughput characteristics to depot cost. The annual depot variable costs are shown in Table 2-8 and the annual depot workload in Table 2-6. It was postulated that the depot variable cost (dependen variable) is

correlated with one or more of the throughput characteristics, i.e., cube, line items shipped and value of materiel (independent variables) which drive depot variable costs. Weight was not used as one of the independent variables because the objective of the transformation process was to develop depot costs per unit of weight (CWT). Linear correlation using the technique of multiple linear regression was used to develop the mathematical relationship between depot variable cost and depot throughput. The results were as f llows:

$$Y(K) = 7{,}256.02 + .00462 \text{ (Line Items Shipped)} \qquad (1)$$

Standard Error = 4,876.03

R^2 = .43

$$Y(K) = 3{,}204.99 + .00400 \text{ (Line Items Shipped)} + .58241 \text{ (Cu. Ft.)} \qquad (2)$$

Standard Error = 4,144.36

R^2 = .60

$$Y(K) = 1{,}993.33 + .00371 \text{ (Line Items Shipped)} + .46925 \text{ (Cu. Ft.)} + 2.88133 \text{ (Value)} \qquad (3)$$

Standard Error = 2,913.56

R^2 = .81

Where:

Y(K) = estimated cost of depot K

Cu. Ft. are in thousands

Value is in millions of dollars

The above series of equations shows that depot cost can be best estimated using three independent variables: equation (3) which uses the three independent variables exhibits the lowest Standard Error and the highest R^2 of the three equations.

b. The standard error of estimate gives a measure of the magnitude of the unexplained variance (i.e., of the variance not attributable to changing the values of line items, cubic feet and value of materiel). R^2 is the symbol denoting another related measure of dispersion called the coefficient of determination. Coefficient of determination shows the proportion of

total variance accounted for by the estimating variables. When all the observed points in the sample are on the least-square line (i.e., if all the historical costs were precisely those predicted by the equation), the coefficient of determination equals 1 and there is no unexplained variance. As the proportion of total variance that remains unexplained increases, the coefficient of determination approaches zero. A coefficient of determination of .81 means that 19 percent of depot costs are due to causes other than the measures of depot throughput used, i.e., line items, cubic feet and value of materiel shipped. The conclusion drawn by the DODMDS study group was that the depot cost estimates obtained by using equation (3) provided a statistically reasonable basis for development of Difficulty Factors.

c. The use of logarithmic and exponential functions in the regression analysis was also explored. The logarithmic function did not improve the correlation results over the linear function. The improvement brought about by using the exponential function was offset by the computational difficulty of apportioning the total system cost among commodity costs so that their sum would equal the sum of depot costs. Consequently, it was decided to use the linear regression results (equation (3)) as the basis for development of Difficulty Factors. Additionally, the use of distribution manhours as the dependent variable in the regression analysis instead of depot variable cost was also explored. The regression results were equivalent.

7. <u>Difficulty Factors Development</u>

a. In order to develop the Difficulty Factors it was assumed that the quantitative relationship expressed in equation (3) applied both to the DODMDS depots from which it was developed and to the DODMDS commodities. This assumption is based on the fact that depot variable cost is driven by the independent depot workload variables, that these variables are the commodity characteristics and therefore the cost of processing each commodity must be driven by the same variables and the same relationship. It should be recognized that the Difficulty Factor concept is a

technique to generate model input data without implying that these Difficulty Factors capture precisely the cost of processing each commodity. The following discussion presents the method of computation of the Difficulty Factors and the problems associated with it.

b. The Difficulty Factors were computed as follows:

$$D(I) = \frac{.493 \times 1{,}993.33 + .00371\ (LIS) + .46925\ (Ft^3) + 2.88133(Value)}{CWT} \quad (4)$$

Where:

o D(I) = Difficulty Factor for commodity I = estimated systemwide cost of commodity I per CWT = standard cost of commodity I

o .493 = Factor used to scale down the mathematical constant (see paragraph d. below)

o 1.993.33 = mathematical constant from equation (3)

o .00371 = coefficient for line items shipped variable from equation (3)

o .46925 = coefficient for the cubic feet variable from equation (3)

o 2.88133 = coefficient for the value variable from equation (3)

o The quantities for line items shipped, cubic feet, value and CWT are systemwide quantities for commodity I.

o The quantities of cubic feet and CWT are in thousands.

o The quantity of value is dollars in millions.

Table 2-10, pages 2.44 and 2.45, lists the Difficulty Factors computed using equation (4).

c. The Difficulty Factors can be computed either on

Table 2-10. Difficulty Factors

Commodity	Difficulty Factors
101 Small Arms	14.49
102 Guns over 75 mm, maj. comp.	13.25
104 Arms & fire control parts	26.53
121 Fire control, reparables	57.36
141 Missiles, reparables, small	127.48
142 Missiles, reparables, large	14.72
144 Missile parts, small	158.15
145 Missile parts, large	342.71
151 Fixed wing acft, reparables	151.84
152 Rotary wing acft, reparables	85.59
153 Acft strct comp, reparables	16.94
154 Acft parts, consumable, med.	20.06
155 Acft parts, consumable, large	16.36
156 Acft parts, consumable, small	54.91
157 Acft parts, cons., very small	164.32
161 Acft eng. components, small	55.98
162 Acft eng. components, large	20.89
171 Ground sup. equip, reparables	17.92
174 Ground sup. equip, consumables	37.37
191 Ships and boats	10.23
204 Ships and boats equip	11.28
221 Railway equip., reparables	05.74
224 Railway equip., consumables	164.50
231 Wheeled vehicles	06.69
232 Combat tracked vehicles	02.83
241 Tractors & constr equip, large	03.95
244 Tractors & constr equip, small	28.10
264 Tires & tubes, non-acft	09.92
265 Tires & tubes, acft	14.15
281 Auto engines, reparables	06.63
294 Auto parts, medium	08.45
295 Auto parts, large	03.32
296 Auto parts, small	19.63
297 Auto parts, very small	90.29
491 Shop equip, reparables, small	59.01
492 Shop equip, reparables, large	06.50
494 Shop equip, consum., medium	09.28
495 Shop equip, consum., large	04.65
496 Shop equip, consum., small	27.36
497 Shop equip, consum., very small	83.37
534 Hardware, large	07.13
536 Hardware, small	13.34
537 Hardware, very small	85.46

Table 2-10. (continued)

Commodity	Difficulty Factors
544 Construction mat'l, small	04.16
545 Construction mat'l, large	02.72
581 Electronics, reparables	38.80
584 Electronics, consumables, med.	12.19
586 Electronics, consum, small	34.68
587 Electronics, consum, very small	191.79
611 Electronics equipment, reparables	06.91
614 Electrical, consumables, med.	30.13
615 Batteries, fuel cells	07.01
616 Electrical, consum., small	40.41
617 Electrical, consum., very small	78.11
651 Medical equipment	26.32
654 Medical supplies, small	10.95
655 Medical supplies, large	53.19
671 Photo equipment	63.90
674 Photo supplies	16.98
684 Chemicals, small	03.04
685 Chemicals, large	01.68
714 House & office eg., small	13.58
715 House & office eg., large	04.49
844 Clothing, small	10.52
845 Clothing, large	11.37
894 Subsistence	02.25
895 DICOMSS	03.26
994 Miscellaneous, small	47.13
995 Miscellaneous, large	38.29

the basis of the system as a whole or for each individual depot. The latter approach is appealing because it explicitly recognizes the differences in commodity composition between depots (commodities are aggregates of NSN's and the mix of NSN's within a commodity may vary between depots). The disadvantages of depot specific Difficulty Factors is that an optimization process can assign commodities to depots which previously did not process those commodities and would not have a Difficulty Factor for that commodity. Consequently, Difficulty Factors were developed on a systemwide basis in order to provide a variable cost for every commodity at every depot.

d. Using equation (3) as the basis for calculation of the Difficulty Factors required a modification of the regression constant when applying this equation to commodities rather than to depots. It was assummed that in the system being studied the sum of depot variable cost of 34 depots must equal the sum of cost of the 69 commodities. Otherwise, the total cost incurred to accomplish system workload at 34 depots would differ from the total cost incurred to accomplish that workload broken down into 69 commodities. To obtain this equality, the regression constant was scaled down for each commodity by the ratio of depots to commodities, i.e., 34/69 = .493 and the same constant applied to all commodities. This method tends to overstate the cost of commodities constituting a small proportion of the system throughput. In the absence of empirical data this simple approach was considered to be adequate.

e. Another aspect of using equation (3) as the basis for development of the Difficulty Factors is that the data base provided by 34 depots covers a smaller spectrum than the parameters of 69 commodities. Extrapolation of a regression equation to estimate a data point outside the range of the data base of that function decreases the accuracy of the estimate. The greater the extrapolation, the less dependable is the estimate. Using equation (3) where three independent variables representing depot throughput are employed, the least dependable Difficulty Factors are for those commodities whose parameters are entirely outside the data base, i.e., whose line items, cubic feet and value quantities of

the commodity are smaller than the smallest or larger than the largest depot. The potential error is less where only two out of three parameters are outside the data base and still smaller where only one parameter is outside the data base. Of the 69 Commodity Difficulty Factors, six are based on three parameters outside the data base (these commodities account for .3 of 1 percent of the CMF total weight shipped), 14 are based on two parameters outside the data base (these commodities account for 7.5 percent of the CMF total weight shipped), 26 are based on one parameter outside the data base (these commodities account for 41 percent of the CMF total weight shipped) and 23 are based on all parameters within the data base. It is recognized that extrapolation of a regression equation reduces the dependability of the estimate, however, in the absence of accounting system cost per commodity, the extrapolations provided the best estimate of depot cost per commodity available.

f. The preceding sections described Difficulty Factors and the problems associated with their development. The Difficulty Factors provide relative depot variable cost per commodity. Although they are not precise depot costs of processing each commodity, they provide reasonable cost inputs to the optimization model based on actual historical DOD experience. The transformation of historical depot variable cost by function into depot cost per CWT per commodity across a diverse system is accomplished by the Difficulty Factor concept within a logical and structured framework. Since the Difficulty Factors are subject to the limited time frame of the data base, the nonuniform micro-mix of commodities at different depots and the extrapolation of the data base, individual depot variable cost rates based on Difficulty Factors are not sufficiently definitive to underpin the optimization analysis.

E. OPTIMIZATION MODEL DEPOT COST INPUT DATA

1. Introduction

The basic model used by the DODMDS study group to assess various structural alternatives is a mixed integer linear programming optimization type model with an objective function to minimize the sum of

depot and transportation cost. The depot cost input data used by this model consists of a fixed cost by depot and variable cost per hundredweight of each DODMDS commodity at every depot. In the course of the DODMDS study, depot variable cost data for input to the optimization model was developed on two bases to support the various model usage strategies. Depot variable cost rates on the basis of historical accounting system costs and historical workload were developed to support model usage strategies involving the baseline, resolution and realignment of the present DODMDS without capital investment. Depot variable cost was also developed using an industrial engineering approach for optimization model usage involving system realignment under the conditions of macro-level investments and is addressed in Section Three of this appendix. In order to conduct sensitivity analysis with respect to depot variable cost for various hypothesized system structures a factor was developed to reflect the differential in local area wage rates. These wage rate differentials were used in conjunction with historical depot costs. The historical depot fixed cost addressed in Paragraph B required adjustment to account for the retail portion of the supply depot operations which are beyond the scope of DODMDS study. An additional facet of the optimization model sensitivity analysis was the development of standardized depot fixed cost to reflect a uniform cost allocation methodology. The last portion of this part addresses the preparation of optimization model input data which evaluates costs associated with the distribution/maintenance interface.

2. Variable Cost

a. Standard Depot Cost

(1) The result of joining the historical depot cost and workload data as described in Part D and reflected in Table 2-10 is depot variable cost per hundredweight for each DODMDS commodity. The depot variable cost developed by the methodology in Part D is a systemwide average cost for each commodity across all depots which handled that commodity in the DODMDS base year. This systemwide average depot variable cost of each commodity is based on the characteristics of all DODMDS depots and the systemwide characteristics of each commodity.

(2) The systemwide average cost per hundredweight per commodity was used for depot variable cost in the optimization analysis. Use of systemwide average cost per commodity was dubbed the "standard depot variable cost" and was employed for structural analysis of the DODMDS for two basic reasons:

(a) Limitation of the Data.

(1) The DODMDS study group historical depot workload and cost data bases reflect only one year of operation. During this time some depots were increasing in workload while others were decreasing; some depots were also undergoing mission changes and substantial alterations in staffing patterns; all of which would impact on depot specific variable costs in a one year period.

(2) The highly aggregated nature of the data representing DODMDS commodities, i.e., model and analytical scale limitations, required that 1.6M active NSN's be aggregated into 69 commodity groups resulting in the application of equal commodity characteristics by commodity across all depots.

(b) Relationship to the Purpose of the DODMDS Study.

(1) The purpose of the DODMDS study was to conduct long range DOD planning and as such was based on, but not dominated by, historical policy or performance, whether that policy or performance was good or bad.

(2) Historical depot variable cost rates, for the most part, are controllable and alterable by specific managerial action within DOD. In the long run, managerial action can be taken, and investment in facilities and materials handling equipment (MHE) made which would minimize differences in the depot variable cost rates, except for regional wage grade differentials in personnel costs. Regional wage grade differentials are treated by sensitivity analysis.

(3) The use of standard depot variable cost in an optimization process implies there are no savings associated with this element of depot costs

and assumes that depot variable cost will migrate with the workload in a realigned system. Another way of stating this is that no savings can be demonstrated by the DODMDS study group by eliminating staffing structures which are shaped by Service/DLA policies for handling historical distribution workloads. In short, the depot variable costs associated with DOD policy are not, prima facie, subject to significant reduction in a realigned system. This conservative assumption is employed to assure that the analysis does not overstate future savings.

b. Optimization Model Baseline

At Army, Navy, Marine Corps, and AF depots, baseline depot variable costs include costs of both wholesale and retail supply operations. At DLA depots retail supply operations are conducted by a base supply service and are reflected in an installation level account. Since the focus of the DODMDS study is to examine the wholesale distribution system, the depot variable cost for optimization model input had to be related to only wholesale distribution. Retail materiel distribution was assumed to continue at the present sites and at the historic volumes. The split of variable cost between wholesale and retail was accomplished by computing variable cost per CWT, a rate, on the basis of total depot workload. Total depot workload includes all shipments whether wholesale, retail, disposal action, interdepot transfer, etc. Variable cost rates reflect no distinction among types of shipments. This single rate per unit of CWT per product was used in conjunction with only wholesale customer demand as input to the optimization model. This enables examination of only those system variable costs associated with wholesale materiel distribution. Table 2-11, page 2.51, reflects baseline variable cost by depot.

c. Wage Rate Differentials

(1) Wage grade adjusted variable costs reflect the variation in personnel cost and subsequently the depot cost between localities which are beyond the control of DOD. These wage costs are driven by DOD local area wage rates which are based on the local

Table 2-11. DODMDS Optimization Model Baseline Variable Cost by Depot (In Millions)

	Baseline Variable Cost
ANAD	9.143
CCAD	3.842
LEAD	9.596
LBAD	3.024
NCAD	14.381
PUAD	2.777
RRAD	11.245
SAAD	8.544
SHAD	7.405
TOAD	5.448
TEAD	8.281
NASALA	3.045
NASJAX	2.159
NASNOR	3.792
NASNI	5.725
NSCNOR	9.355
NSCOAK	10.707
NSCPH	.381
NSCSD	2.414
MCAS	2.499
OCALC	19.659
OOALC	11.334
SMALC	8.600
SAALC	16.717
WRALC	10.349
MCLSBLANT	1.948
MCLSBPAC	3.818
DCSC	10.734
DDMP	21.278
DDMT	21.015
DDOU	17.818
DDTC	18.308
DESC	8.641
DGSC	15.925
TOTAL	309.906

average commercial industrial wages.[1] It was therefore determined that a set of factors or multipliers be developed for sensitivity analysis which could be used to adjust the commodity specific standard depot variable costs to reflect these local wage rate differences between the 34 DODMDS depots.

(2) The DOD Wage Fixing Authority wage rate schedules were used as the basis for developing geographic wage rate indices applicable to each of the DODMDS depots and/or clusters. Wage grade nine, step four (WG9-4) was found to historically approximate the average hourly supply depot operations (SDO) wage in the DODMDS. The hourly wage for a WG9-4 was extracted from the applicable schedules provided by the DOD Wage Fixing Authority for each of the 34 DODMDS depots (Table 2-12, page 2.53, Col. 1). Since the wage rate schedules are not all set at one time, the effective dates varied from August 1975 through July 1976. The average WG 9-4 from the schedule for all 34 locations was \$6.73/hour. The depot whose schedule was historically nearest to \$6.73 was MCAS Cherry Point with \$6.72/hour. MCAS Cherry Point was therefore given a factor of 1.00. The WG9-4 hourly rates for each of the remaining 33 depots were then divided by \$6.72 to derive a depot specific factor relative to MCAS Cherry Point (Table 2-12, Col. 2). These indices do not consider the general schedule (GS) personnel labor rates and therefore reflect a maximum dispersion between depots (0.86 to 1.16 or 30 percent). To correct for the GS personnel impact, i.e., equal salary by grade for all depots except NSC Pearl Harbor, the percent of total depot variable costs which are wage grade related were calculated. Wage grade related variable costs were assumed to be represented by DODI 7220.17 receiving, packing, bulk and bin issue, shipping, container assembly, unit and set assembly, care of materiel in storage, rewarehousing, preservation and packaging, and receipt document processing functions. The depot variable costs for these functions were divided by the total

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[1] Reference DODI 5120.39 (DOD Wage Fixing Authority) and Federal Personnel Manual Supplement 532-1.

Table 2-12. <u>Geographic Wage Grade Multiplier</u>

Depot	(1) Wage Grade $/Hour*	(2) Wage Grade Factor	(3) Percent Wage Grade Related	(4) Wage Grade Mult. #1 Depot Spec.
ANAD	6.16	.92	68	.95
CCAD	6.75	1.00	61	1.00
LEAD	6.52	.97	69	.98
LBAD	6.39	.95	73	.96
NCAD	6.61	.98	65	.99
PUAD	6.61	.98	74	.99
RRAD	6.26	.93	66	.95
SAAD	7.58	1.13	69	1.09
SHAD	6.93	1.03	65	1.02
TOAD	5.76	.86	73	.90
TEAD	6.79	1.01	70	1.01
NASALA	7.77	1.16	69	1.11
NASJAX	6.91	1.03	71	1.02
NASNOR	6.19	.92	69	.94
NASNI	6.63	.99	63	.99
NSCNOR	6.19	.92	67	.95
NSCOAK	7.77	1.16	60	1.10
NSCPH**	7.58	1.13	69	1.14
NSCSD	6.63	.99	72	.99
MCASCP	6.72	1.00	64	1.00
OCALC	6.61	.98	53	.99
OOALC	6.79	1.01	48	1.00
SMALC	7.58	1.13	47	1.06
SAALC	6.19	.92	54	.96
WRALC	6.69	1.00	53	1.00
MCLSBLANT	6.02	.90	71	.93
MCLSBPAC	7.07	1.05	60	1.03
DCSC	6.65	.99	70	.99
DDMP	6.61	.98	70	.99
DDMT	6.51	.97	75	.98
DDOU	6.79	1.01	78	1.01
DDTC	6.93	1.03	72	1.02
DESC	7.01	1.04	71	1.03
DGSC	6.49	.97	69	.98

* Wage for WG-9, Step 4, effective date between August 1975 through July 1976.

**NSC Pearl Harbor had a 17.5 percent cost of living differential for GS personnel (69 percent Wage Grade X 1.13 Wage Grade Factor) + (31 percent GS Grade X 1.175 Differential) = 1.14 Wage Grade Multiplier.

depot variable cost to produce the percent of wage grade related costs for each depot (Table 2-12, Col. 3). These wage grade percentages and the wage grade factors previously calculated, were used to calculate depot specific wage grade index multipliers (Table 2-12, Col. 4). The wage grade index multiplier for each depot equals the summation of depot wage grade factor times the percent of wage grade related total variable cost plus the depot GS factor (1.00 for all depots except NSC Pearl Harbor with 1.175 to account for the GS cost of living differential) times the GS percent of total variable cost. For example, for Anniston Army Depot: the Wage Grade Multiplier = (0.92 x 0.68) + (1.00) x (1.00 - 0.68) = 0.95.

(3) Column 4 of Table 2-12, is depot multipliers reflecting the variation in local area wage rates. These multipliers were used to adjust the standard depot variable cost per hundredweight by DODMDS commodity for optimization model input data in sensitivity analysis.

3. Fixed Cost

a. Optimization Model Baseline

(1) Historical depot fixed costs were developed for the total distribution mission, including wholesale and retail, at Service depots as specified in Part B . The total fixed cost of each Service depot was then adjusted for the volume of retail activity which was assumed to remain unchanged for each depot. The fixed costs of the DLA depots were not adjusted for the retail issue volume since the DLA depot fixed cost data is applicable only to wholesale materiel operations.

(2) The split of fixed costs between wholesale and retail cannot be accomplished cleanly. Fixed costs are composed of installation overhead costs for management, facility, ADP and base transportation services to support the materiel distribution mission. Depot fixed cost in an optimization process represents the cost to open specific depots and

therefore the potential savings associated with not opening them. Since the amount of retail activity at Service depots represents workload which will be ongoing at these sites, some portion of fixed costs to support the retail activity will continue . In order to estimate the portion of fixed costs applicable to wholesale workload several prorating schemes were devised. Table 2-13, page 2.56, shows fixed costs by depot and the percents related to wholesale workload when prorated on the basis of workload measured in line items shipped and CWT shipped. Deriving percents of wholesale to total, using a single workload descriptor of lines or CWT, produces a shift of between 15 to 55 percent for 12 of the 27 depots requiring the split. To overcome the problem associated with using any single workload measure to prorate, the results of applying both percents to total fixed costs at each depot were averaged. The averaged wholesale fixed costs in Table 2-12, Col. 8 were used as depot fixed costs for optimization model inputs.

b. Standardized

Paragraph B of this Section delineated some of the data anomalies and inconsistencies associated with the DODMDS study group's accumulated historical depot fixed costs. In order to overcome these data anomalies and inconsistencies the DODMDS study group developed alternative fixed cost data for every depot by applying a uniform allocation technique for major fixed cost elements at each depot. These depot fixed cost data were dubbed "standardized depot fixed cost." The results of the standardized depot fixed cost for each depot are reflected in Exhibit 2-3, page 2.88 through 2.124. The standardized depot fixed cost data are an approximation to the depot fixed costs using simplified and uniform allocation techniques. The data in Exhibit 2-3 forms a set of depot fixed cost data for use in subsequent optimization sensitivity analyses.

Table 2-13. Wholesale/Retail Split Dollars In Thousands

(1) Depot #	(2) Depot	(3) Total Fixed Cost	(4) Wholesale Line Items Shipped Percent	(5) Wholesale Fixed Cost (3 x 4)	(6) Wholesale CWT Shipped Percent	(7) Wholesale Fixed Cost (3 x 6)	(8) Average of Cols. 5 and 7
01	ANAD	4182	.26	1087	.81	3387	2237
02	CCAD	2187	.12	262	.49	1072	667
03	LEAD	4439	.61	2708	.74	3285	2997
04	LBAD	3354	.54	1811	.41	1375	1593
05	NCAD	5169	.81	4187	.84	4342	4265
06	PUAD	2949	.43	1268	.81	2389	1829
07	RRAD	7013	.74	5190	.45	3156	4173
08	SAAD	5190	.65	3374	.60	3114	3244
09	SHAD	3826	.59	2257	.70	2678	2468
10	TOAD	5255	.55	2890	.63	3311	3101
11	TEAD	6006	.52	3123	.83	4985	4054
12	NASALA	2631	.71	1868	.76	2000	1934
13	NASJAX	1657	.65	1077	.50	829	953
14	NASNOR	1674	.88	1473	.81	1356	1415
15	NASNI	2291	.80	1833	.67	1535	1684
16	NSCNOR	8271	.77	6369	.59	4880	5625
17	NSCOAK	8562	.92	7877	.88	7535	7706
18	NSCPH	2095	.23	482	.28	587	535
19	NSCSD	3369	.21	707	.55	1853	1280
20	MCASCH	2278	.56	1276	.61	1390	1333
21	OCALC	4853	.57	2766	.62	3009	2888
22	OOALC	4214	.44	1854	.59	2486	2170
23	SMALC	4048	.34	1376	.49	1984	1680
24	SAALC	4699	.59	2772	.54	2537	2655
25	WRALC	4141	.49	2029	.57	2360	2195
26*	MCLSBLANT	5675	.34	1930	.78	4427	3179
27*	MCLSBPAC	5790	.78	4516	.87	5037	4777
28	DCSC	9052	1.00		1.00		9052
29	DCMP	4420	1.00		1.00		4420
30	DDMT	7079	1.00		1.00		7079
31	DDOU	8547	1.00		1.00		8547
32	DDTC	7264	1.00		1.00		7264
33	DESC	5642	1.00		1.00		5642
34	DGSC	5825	1.00		1.00		5825

* See on next page.

* a. Marine Corps Logistics Support Bases report some SDO costs for retail operations separately from wholesale operations. Because the use of separate account structures for wholesale and retail does not extend to every functional area the overall DODMDS approach to wholesale/retail split of fixed costs was adopted for both LSB's.

b. The total fixed cost of the MCLSB's shown above was used for the development of the wholesale fixed cost used in the optimization modeling. These fixed costs differ from the costs shown in Chapter 3, Table 3-11, page 123, (Reference: HQ USMC letter LMP/DEB/sp 500 dated 29 September 1977, subject: Comments on DODMDS Chapters 1, 2 and 3 and DODMDS letter dated 5 October 1977, same subject). The difference between the two sets of costs did not affect the outcome of modeling analysis actually used as inputs.

4. Distribution/Maintenance Interface

a. An area of concern regarding collocation of distribution and maintenance activities was the correct representation of system costs resulting from depot/customer combinations which differ from historical product flows. DODMDS recommendations for depot/customer combinations should consider all pertinent costs and any "new" costs to DOD resulting from system realignment must be explicitly identified and incorporated into the economic analyses leading to recommendations.

b. The prime area of interest in this regard was the handling of reparable items, specifically, the cost implications associated with decollocating reparable product storage from the historic depot maintenance sites.

c. The least cost solution criteria used by the optimization model should apply to all collocated and non-collocated depot/customer combinations. That is, in selecting product flows between depots and customers the model seeks to minimize the total cost of inbound transportation plus depot costs plus outbound transportation charges. For collocated distribution/maintenance combinations for reparable products, there was no "new" cost if inbound flows of unserviceable reparables were directed to the collocated distribution activity. The optimization model will assess an inbound charge plus a depot handling charge plus an outbound charge. For collocated distribution/maintenance combinations the outbound transportation charge was zero (local delivery). Similarly, the model will assess the same three charges if the reparable products move through a non-collocated distribution activity, except that outbound transportation between the non-collocated distribution facility and maintenance will now be positive. However, this latter case does not cover all the cost to DOD. A maintenance facility does not have a receipt, store and issue capability. Maintenance relies on the collocated distribution organization to perform the supply support function. As discussed before, costs associated with retail

operations were considered ongoing. The amount of retail business measured in lines, CWT, etc. translates to a lump sum of retail variable cost which is set aside along with retail fixed cost. However, the retail volume did not include reparable issues to maintenance as portrayed in DODMDS customer demand files. Therefore, a means had to be devised to incorporate the continuing cost of processing wholesale reparable items at the maintenance location.

d. To illustrate this requirement consider the following example: workload at a distribution facility collocated with a maintenance facility historically consisted of 100 issues comprised of 60 wholesale and 40 retail. Of the 60 wholesale issues 10 were on-base issues of reparables to collocated maintenance. If the model in deriving the least cost solution, flows all 60 wholesale issues through a non-collocated distribution activity, the level of activity which will continue at the collocated distribution center will consist of the 40 retail transactions plus the 10 issues of reparables which are tied to their historic maintenance site. Total issues will increase to 110. The difference in system cost associated with flowing the 60 wholesale issues through a non-collocated distribution organization must be partially offset by the continuing cost to handle reparable products at the maintenance site.

e. This continuing depot cost is overlooked in an optimization model because it occurs below the wholesale level. The "new" cost of processing this workload at the historic maintenance site must be represented in the model in the form of a penalty charge for decollocation. The means for assessing this penalty cost is as follows: on outbound links for reparable products in unserviceable condition between historically collocated maintenance sites and non-collocated distribution centers, add to the basic transportation cost the variable cost for processing the reparable product at the historically collocated distribution site. This penalty charge is referred to in mathematical notation as U'ik to distinguish it from the basic variable cost of reparable product i at depot k, or Uik. By this means, the optimization

model cost will reflect the collocated depot variable cost for reparable product i regardless of how the model flows the product.

f. By incorporating the ongoing cost of processing reparables at their historic maintenance sites into the economic analysis, depot/customer combinations for reparable products are permitted to float like any other product, thus avoiding the alternative which is to lock open depots collocated with maintenance at the minimum level of wholesale activity related to reparable issues to maintenance.

g. Table 2-14, page 2.61, shows the potential U'ik penalty costs associated with the historical unserviceable reparable workload at each Service depot. Note that DLA depots/centers experienced no unserviceable reparable workload in the DODMDS base year.

Table 2-14. Distribution/Maintenance Interface

Depot No.	Depot	Potential U'ik ($000)
1	ANAD	3690
2	CCAD	2219
3	LEAD	2811
4	LBAD	1138
5	NCAD	1878
6	PUAD	799
7	RRAD	2005
8	SAAD	1934
9	SHAD	2227
10	TOAD	1832
11	TEAD	3175
12	NASAL	641
13	NASJAX	257
14	NASNOR	367
15	NASNI	849
16	NSCNOR	48
17	NSCOAK	131
18	NSCPH	2
19	NSCSD	137
20	MCASCP	389
21	OCALC	6732
22	OOALC	2235
23	SMALC	2791
24	SAALC	3267
25	WRALC	3619
26	MCLSBLANT	158
27	MCLSBPAC	141

Note: Potential U'ik dollar values were computed by multiplying the CWT of individual unserviceable reparable products demanded by collocated customers in the base year by the difficulty factor for each product and then summing across all reparable products to produce individual depot potential U'ik.

EXHIBIT 2-1

A. ARMY DEPOTS

1. Costs for excluded functions include related installation services costs except in the case of stock control. Stock control costs are memo entry costs in the 238 report. That is, their costs are incorporated into the in-shop and above-shop overhead rates prescribed by Army Industrial Fund (AIF) procedures for allocating overhead charges to specific functional accounts.

2. The following notes are for the individual entries in Table 2-1-1, page 2.65.

a. DARCOM, in conjunction with DESCOM, identified no candidates for exclusion as non-SDO.

b. Differences in distribution structures and missions within DOD necessitated making a split of costs for stock control (DODI 7220.17 account 1.2x). The split required for comparability is between stock control costs related to receiving documentation versus all other stock control costs. The former costs are part of distribution supply production, while the latter costs are an admixture of individual Service prerogatives in organizational structure, data processing procedures, stock accountability, and customer service functions. There has been no split of stock control charges for DARCOM depots. During a DODMDS study group visit to Depot Systems Command (formerly USAMIDA) on 24 August 1976, Army personnel indicated that receiving documentation processing was charged to the functional account for receiving at some DARCOM depots and to one of the stock control accounts at other DARCOM depots. Depot Systems Command personnel on a previous visit by DODMDS representatives indicated that the Depot Property Division performed stock control functions for on-base customers, primarily depot maintenance, in FY 75. The costs incurred by Depot Property Division were charged to Base Operations Z Account B1000, Post Supply Operations, and prorated to depot mission accounts as

part of installation overhead. The differences in stock control charges reported by individual depots due to local interpretation of AR 37-100-75 account descriptions and the lack of uniformity have resulted in a determination to exclude all stock controls costs reported against AMS codes 212, 222, and 232 and accept the presence of some undisclosed amounts of stock control costs in the DARCOM depot costs.

c. NCAD and SHAD incurred costs in FY 75 for Containerization and Consolidation Points (CCP). This function is part of Water Port of Embarkation (WPOE) charges for the other Services and has therefore been incorporated into transportation rates to be used in model analysis. The CCP costs reported had therefore to be excluded from NCAD and SHAD distribution mission costs. RRAD reported no CCP costs in FY 75. DSS Scrub Team costs were excluded in conjunction with CCP costs.

d. DODMDS policy required that SDO reported costs associated with ammunition workload be excluded from model analysis because of the unique storage and handling requirements of this materiel. The account structure in the 238 report permits the separate collection of distribution costs for ammunition and general supplies except in traffic management. In order to exclude a portion of traffic management for ammunition workload a proration of the costs recorded against AMS codes 310, 340, and 390 was made based on ammunition short tons as a percent of total short tons received and shipped. Since approximately 98 percent of the lines at the six DARCOM depots with ammunition workload were for general supplies, the proration was deemed equitable. Traffic management costs were used in their entirety.

e. These functions were not considered an integral part of wholesale materiel distribution. Workload accomplished was not included in DODMDS master shipment file.

f. ANAD and NCAD costs for procurement of capital equipment were excluded as exceptionally high one-time expenses associated with modernization projects at those two depots.

g. Severance pay costs at LBDA and PUDA were excluded because they were one-time expenses which occurred outside the scope of the distribution mission.

EXCLUSION CRITERION	EXCLUDED FUNCTION	ACCOUNT	NOTE	DEPOT ABBR. / SEQUENCE NO. / DEPOT RIC	ANAD 1 BA	CCAD 2 BS	LEAD 3 BK	LBAD 4 BL	NCAD 5 AN	PUAD 6 BP	RRAD 7 BR	SAAD 8 BS	SHAD 9 AQ	TOAD 10 BY	TEAD 11 BT
Non-SDO			a												
Non-Comparable SDO	Stock Control	200	b		294	10	482	328	384	-	280	510	154	165	-
	Containerization & Consolidation Point (CCP)	14421	c		-	-	-	-	2663	-	-	-	1810	-	-
	DSS Scrub Team	13641			-	-	-	-	94	-	289	-	23	-	-
DODMDS Policy	Ammunition	Various	d		5503	-	5199	4396	-	3219	5290	-	-	-	5817
SCTG Policy	Passenger Processing	320	e		19	-	18	50	15	15	28	15	13	30	22
	Household Goods	330	e		-	14	2	277	11	-	107	7	174	141	-
One-Time Expenses	Procurement of Capital Equipment	942	f		1150	-	-	-	329	-	-	-	-	-	-
	Severance Pay	-	g		-	-	-	538	-	642	-	-	-	-	-
	Total				6966	24	5701	5589	3496	3876	5994	582	2224	336	5839

Table 2-1-1. Army

B. NAVY DEPOTS

1. Costs of excluded functions do not include costs of installation services. Installation services costs charged to distribution at these activities have been adjusted to reflect the effect of excluding the manyears and a limited range of facilities associated with the excluded functions.

2. NSCs record the 2000 series of cost accounts against subfunctional (S/F) category code A5, Supply Operations. The only non-2000 account which appears against S/F A5 is the occasional use of 1111, a cost account used to transfer costs from another S/F code, e.g., DP-Data Automation, to S/F A5. NASs and MCAS Cherry Point employ S/F E1 for SDO costs. Non-2000 series accounts, e.g., for minor property, appear against S/F E1, but have not been included as SDO costs for these activities.

3. Following notes describe the functions contained in Table 2-1-2, pages 2.71 and 2.72.

a. Purchase and Contract Administration are reported in the 2000 series of NAVCOMPT/NAVSUP accounts used for SDO by NASs, NSCs, and MCAS Cherry Point. Costs for these two functions were excluded from SDO costs because these functions are procurement operations by DODI 7220.17 definition.

b. NAVSUP letter of 1 June 1976, subject: DODMDS Supply Depot Cost Data, indicated that the functions charged to the following special project codes were non-SDO functions. They were excluded from depot costs:

NAVSUP Special Project Account	FUNCTION
2901	Navy Materiel Transportation Office (NAVMTO) is a staff function whose cost was incurred only at NSC Pearl Harbor.

2904	Supply Availability Operations includes liaison with shipboard personnel upon commencement of supply overhauls. Costs were incurred at NSCs Oakland, Pearl Harbor and San Diego.
2908	Fitting Out Supply Assistance Teams indoctrinate prospective commanding and supply officers in administration of shipboard supply departments before ships' commissioning for active duty. Cost incurred only at NSC Norfolk.
290A	Naval Logistics Engineering Group incurred cost only at NSC Norfolk.
)63/5	Fleet Reparables Assistance Agents incur costs at each of the NSCs in support of the Improved Reparables Asset Management Program, NAVSUP instituted program for intensive management of CLAMP and FIRM items.

c. The 1 June 1976 NAVSUP letter also indicated the Outfitting and Allowance Revision (NAVCOMPT account 2146) should be considered as a non-SDO function. It includes physical handling incident to the assembly and custody of allowance list material previously expended from stock records and set aside for commissioning, conversion, or reactivation of ships. The charges for this function at NSCs Norfolk, Oakland and San Diego were excluded.

d. Costs for library operations, that is, receiving, storing and issuing of library books, maintenance of stock records for library books, and related support, were incurred only at NSC Norfolk.

Issues of library books are not part of the DODMDS depot workload files, therefore costs for this function were excluded.

e. Food Services Division of the Supply Departments at each NAS and MCAS Cherry Point operate and maintain a messing facility for military personnel. Costs of this function were not reported in SDO costs, however, manyears shown were subtracted from Supply Department population at applicable depots prior to calculation of installation services costs in support of distribution.

f. Differences in distribution structures and missions within DOD necessitated making a split of costs for Stock Control (DODI 7220.17 account 1.2x). The split required for comparability was between stock control costs related to receiving documentation versus all other stock control costs. The former costs are part of basic supply production while the latter costs are an admixture of individual service prerogatives in organizational structure, data processing procedures, stock accountability, and customer service functions. For NSCs receiving documentation charges are those charges reported against NAVSUP account 2222, Receipt Control Program Management. All other NSC stock control charges were excluded as non-comparable. NASs and MCAS Cherry Point had to segregate the portion of stock control charges for receiving documentation from all other stock control charges because these activities use the NAVCOMPT account structure for SDO which does not provide a separate account for receipt control processing. All other NAS and MCAS stock control charges were excluded as non-comparable.

g. The four NSCs perform waterport and/or seavan container operations and report the associated costs as SDO costs. DODMDS transportation rates include costs for waterport operations, container "stuffing and stripping", and documentation in support of Defense Transportation System (DTS) cargo controlled by Military Traffic Management Command (MTMC). Therefore, the SDO costs associated with these functions were excluded from baseline depot costs

to prevent duplication of costs for the same functions in both depot and transportation costs. To do this required dividing waterport operations into two categories:

(1) Manifested (DTS) Navy and non-Navy break bulk and containerized cargo which are loaded/unloaded on commercial or Military Sealift Command (MSC) ships, and

(2) Non-manifested water cargo which is loaded/unloaded on Navy ships and, in special haul cases, Navy and commercial ships.

SDO costs associated with the first category are for (1) waterport operations charged to the NAVCOMPT accounts which correspond to the DODI 7220.17 general functional area 1.5, Waterfront Operations; (2) container stuffing and stripping charged to NAVCOMPT accounts for receiving, packing and shipping; and (3) documentation charged to the NAVCOMPT account for traffic management. Each NSC identified, by NAVCOMPT account, that portion of the Activity Management Report costs and manhours reported for the DODMDS base year which were incurred for manifested water cargo.

Costs for non-manifested cargo are for the remainder of waterfront operations at NSCs and for waterfront operations conducted at two NASs. These costs were not included in DODMDS transportation rates and could therefore be included as depot cost in model runs in conjunction with other service/agency unique mission costs or excluded entirely.

h. Maintenance Support Package (MSP) is an NAS mission involving the assembly, restocking and storage of cabinets containing aircraft maintenance support parts for use aboard ship. Expenses are charged to the 2146 cost account. MSP stock is pre-expended, that is, has no ICP visibility and cannot be issued to non-MSP customers without COMNAVAIRPAC or COMNAVAIRLANT approval. Because there are no corresponding workload data in the DODMDS data base

and it is done at only NAS North Island for COMNAVAIRPAC and NAS Norfolk for COMNAVAIRLANT, the function was excluded as non-comparable SDO.

i. Aviation Support Divisions, variously referred to as Fleet Support, supply support, etc, have been excluded as non-comparable because the work accomplished is considered by DODMDS to be at the customer level. Functions include customer service, bench stock processing, expedited on-base delivery, preparation of requisitions, all in support of flying squadrons and intermediate level maintenance. Most of the charges for Aviation Support at the NASs are recorded as stock control charges and therefore excluded with stock control costs. Costs shown against Aviation Support in Table 2-1-2 are only the costs recorded against other than stock control accounts.

j. Bulk fuel operations were excluded from SDO costs by DODMDS policy decision, because of the unique handling and storage characteristics of this materiel. NAS Alameda reported costs for specific fuel operations against individual accounts established locally: Liquid Oxygen/Nitrogen Distribution--2147, Aircraft Refueling--2148, and Retail Refueling--2149. These costs were excluded as Bulk Fuel Costs.

k. Manyears and costs associated with processing of perishable subsistence at the NSCs were excluded from DODMDS modeling analysis due to the unique storage and handling requirements of the materiel. Because the data initially provided by NAVSUP was at a summary level, it was necessary for DODMDS to obtain additional cost, manhour and/or workload data, to determine costs and manyears by cost account from each NSC. Since DODMDS demand data does not include Navy managed commissary or Navy exchange items, costs associated with processing these materials through the NSCs had to be excluded. In excluding costs for manifested water cargo and perishable subsistence, the costs related to these items were excluded.

l. These functions are not considered by DODMDS to be an integral part of wholesale materiel distribution. Workload accomplished is not included in DODMDS master shipment file for use in model analysis.

m. No one-time expenses which would make the SDO cost data atypical were reported by the Air Stations or Supply Centers.

n. MCAS Cherry Point identified one-time costs for aircraft fuel ($129K recorded against special project code 2900) to be used in an aircraft test project funded by COMNAVAIRSYSCOM. These costs were excluded.

DOLLARS IN THOUSANDS

EXCLUSION CRITERION	EXCLUDED FUNCTION	ACCOUNT	NOTE	DEPOT ABBR. / SEQUENCE NO. / DEPOT RIC	NASAL 12 PA	NASJAX 13 PT	NASNORVA 14 PN	NASNI 15 PD	NSC NORVA 16 NN	NSCO 17 NO	NSCPH 18 NP	NSCSD 19 ND	MCASCP 20 PT
Non-SIMI	Purchase	2700	a		185	222	216	300	1097	1594	473	315	241
	Contract Administration	2800			-	-	-	31					
	NAVMTO	2901	b		-	-	-	-	-	-	121	-	-
	Supply Avail Ops	2904	b		-	-	-	-	-	70	56	192	-
	FOSAT	2908	b		-	-	-	-	144	-	-	-	-
	NLEG	290A	b		-	-	-	-	179	-	-	-	-
	FMAA	2963/5	b		-	-	-	-	57	11	26	38	-
	Outfitting & Allowance Revision	2146	c		-	-	-	-	207	81	-	2	-
	Library Operations	2905	d		-	-	-	-	67	-	-	-	-
	Food Services (in Manyears)	9900	e		31MY	56MY	47MY	37MY	-	-	-	-	172MY
Non-Comparable SIMI	Stock Control	2200	f		646	842	1381	1059	2764	4249	681	2144	1045
		2500			-	-	-	604	-	-	-	-	106
	Water Cargo Manifested	2100/2150 2310	g		-	-	-	-	8339	966	2200	314	-
	Non-Manifested	2150			107	-	-	141	1059	-	325	14	2
	Maintenance Support Pkg (MSP)	2146	h		-	-	158	503	-	-	-	-	-
	Aviation Support		i		226	45	140	535	-	-	-	-	-
INHMDS Policy	Bulk Fuel	2141	j		761	376	341	561	1553	301	1047	823	245
	Misc Fuel Ops	*2147-8-9			308	-	-	16	-	-	-	-	-
	Perishable Subsistence (Provisions)	Various	k		-	18	-	-	676	1441	311	139	-

* At NASs Liquid Oxygen/Nitrogen Fueling

Table 2-1-2. Navy

DOLLARS IN THOUSANDS

EXCLUSION CRITERION	EXCLUDED FUNCTION	ACCOUNT	NOTE	DEPOT ABBR. SEQUENCE NO. DEPOT RIC	NASAL 12 PA	NASJAX 13 PT	NASNORVA 14 PN	NASNI 15 PD	NSC NORVA 16 NN	NSCO 17 NO	NSCPH 18 NP	NSCSD 19 ND	MCASCP 20 PT
SCTG Policy	Customer Service Stores (SERVMARTS & Ready Supply Stores)	2142 **2147	1		- -	324 -	- -	26 -	342 39	197 5	176 24	644 29	147 -
	Passenger Processing	2320	1		-	-	-	-	-	-	-	-	8
	HHG	2330	1		1	218	-	-	1444	666	884	746	92
One-Time Expense	To Be Determined		a										
	Aircraft Test Project	2900	a		-	-	-	-	-	-	-	-	129
	Total				2234	2045	2236	3776	17967	9581	6324	4400	2015

** At NSCs Shop Stores

Table 2-1-2. (Continued)

C. AIR FORCE DEPOTS

1. Costs for excluded functions do not include related installation overhead costs. However, costs for excluded functions as shown in Part III include Overall Depot Support (DODI 7220.17 account 1.9) charges for the individual excluded functions which Air Force Logistics Command identified as necessary to complete cost exclusions for the Directorate of Distribution (DS) at each Air Logistics Center.

2. Following notes pertain to the excluded functions shown in Table 2-1-3, page 2.79.

a. Installation Equipment Management Offices (IEMO) at ALC's direct and control all authorization and assets of equipment for mission requirements of the installation and tenant organizations. This function is an appropriate installation overhead charge by definition. The costs for IEMO charged to Overall Depot Support (DODI 7220.17 account 1.9) were extracted from SDO costs and added to installation overhead for proration as part of Management Services.

b. Packaging and Materiel Handling personnel at each ALC exercises management control and provides technical direction, worldwide, for packaging and materiel handling of items for which the ALC has materiel management responsibility. This is essentially an Inventory Control Point (ICP) function and has therefore been excluded.

c. Costs for the DOD Dog Center at San Antonio ALC were excluded because this organization functions as program manager for military working dogs and related equipment and supplies. This non-SDO mission entails the commodity management, procurement, care and feeding, and distribution of dogs for DOD and other government agencies. The Dog Center is organizationally assigned to the Directorate of Distribution at SAALC and was charged to DODI 7220.17 account 1.9, Overall Depot Support.

d. Special Weapons function is unique to SAALC and represents distribution support of the management of nuclear items mission at SAALC. The functions

performed by Special Weapons personnel were not identifiable as receipt, store, or issue activity, since costs of these functions are reported only at the 1.9 account level. Because nuclear items will not be input to model analysis the costs of these functions were excluded.

e. (1) Differences in distribution structures and missions within DOD necessitated making a split of costs for Stock Control (DODI 7220.17 account 1.2x). The split required for comparability was between stock control costs related to receiving documentation versus all other stock control costs. The former costs are part of basic supply production while the latter costs are an admixture of individual service prerogatives in organizational structure, data processing procedures, stock accountability, and customer service functions. An extreme example of the diversity of charges reported against stock control accounts was a charge in excess of $2M for materiel and supplies issued to commercial rework facilities by MCAS Cherry Point.

(2) For ALCs, charges by the central receiving function to DODI 7220.17 account 1.22, Other Stock Control Operations, were considered to be for receiving documentation and included in depot costs. The remainder of the charges recorded against 1.22, all charges against DODI 7220.17 account 1.21, Requisition Processing and charges against three AFLC unique accounts for Stock Control -- 1.23, Base Commodity Management; 1.24, Stock Control Training; and 1.29, Stock Control Support -- have been excluded as non-comparable SDO costs. Additional charges for stock control support to be excluded were determined to be charges against DODI 7220.17 account 1.9, Overall Depot Support, for organizations which perform the basic stock control functions. The values calculated and included in depot costs for receiving documentation have been confirmed by HQ AFLC.

f. Air terminal operations for DODMDS purposes are defined as those ground support functions, i.e., air cargo handling, pallet build up, aircraft loading/unloading, pallet teardown, cargo segregation,

and document/manifest preparation and processing, required to support the LOGAIR and QUICKTRANS airlift capability.

(1) ALCs are the only Service/Agency depots which report the costs of performing air terminal operations as SDO costs against DODI 7220.17 accounts 1.4x, Air Cargo Operations.[1] Having this service unique capability is an integral feature of the AFLC logistics posture. Other distribution activities within DODMDS serviced by a DOD-managed air terminal activity include NSC's Norfolk,, Oakland, and San Diego and the four NASs.

(2) In the interests of comparability, costs of air terminal operations were excluded as non-comparable SDO. Total air terminal costs excluded from costs consist of costs reported against DODI 7220.17 accounts 1.4x (less 1.42) plus the additional air terminal costs reported against DODI 7220.17 account 1.9, Overall Depot Support.

g. Another result of ALC prerogatives in the organization/accounting system appears in costs related to management and installation service type functions which are performed within the DS organization and charged to the 1.9 account. There are two entities in DS which fit this category: the Management Services Division (DSM) which provides administrative support, production control, industrial engineering, and plans and analysis; and the Facilities Services Branch (DSFF) which provides in-house maintenance, modification and/or installation of all materiels handling equipment, storage aids, and directorate property other than real property or vehicles.

(1) At depots where these support functions were performed by an installation level organization rather than a supply organization, the costs were allocated as part of installation overhead using for example,

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[1] 1.42 Air Passenger Processing has been excluded under the criteria contained in paragraph 21, page 2.78, and not considered in this discussion.

the ratio of distribution population to total installation population. In this way, management services costs in support of distribution did not include management services related to an excluded function; like bulk fuel operations. The effect was to include only a portion of the costs for installation type services.

(2) An anomaly in ALC distribution costs was produced because the costs of those functions were incorporated into distribution costs and not subjected to an allocation procedure. The problem, therefore, to be overcome was that management and facilities services in support of excluded functions were included as costs in the 1.9 account for each ALC.

(3) The means of minimizing the anomaly was to prorate the DSM and DSFF charges to 1.9 on the basis of the ratio of distribution population to total DS population. The difference between total DSM and DSFF charges and prorated DSM and DSFF charges was subtracted from the 1.9 total charges for each ALC and appears in Table V 2-1-3 as Management/Facilities Services.

h. Depot Support Branch (DSDM) charges to other than stock control (1.2) accounts have been excluded as non-comparable SDO costs since they cover on-base customer support including bench stock processing, expedited deliveries, maintenance liaison, part number research for tenants, etc. At Oklahoma ALC, DSDM also includes functions performed by base motor pool at the other ALCs in FY 75. An estimate of the costs associated with these functions has been included in base transportation charges to distribution at OCALC.

i. DODMDS policy requires that depot costs associated with ammunition workload be excluded from model analysis because of the unique storage and handling requirements of this materiel. Therefore, costs for the Munitions Supply Division (DSY) and the Airmunitions Traffic Management section (DSPPT) were excluded at Ogden ALC.

j. Ogden ALC incurred charges against the 1.9 account in FY 75 for ammunition storage contracts with Army and Navy storage activities. Costs related to

ammunition storage were excluded by DODMDS policy decision as in paragraph 2i, page 2.77.

k. Bulk Fuel operations were excluded from depot cost by DODMDS policy decision because of the unique handling and storage characteristics of this materiel.

l. These functions were not considered by the study group to be an integral part of wholesale materiel distribution.

m. Contractual services to be excluded as one-time expenses include costs for installing storage aids at Sacramento ALC; storing C-5A aircraft tooling for SAALC; off-base storage of drones, revetment kits, missiles, shelters, modular relocatable buildings, and trucks for Warner Robins ALC; and activation of the Avionics Warehouse at WRALC.

n. End of year purchase of supplies in anticipation of shortages in raw materials was considered a one-time expense by SMALC and WRALC.

o. The cost identified by SAALC represents the cost of excess manpower assigned to the Directorate of Distribution pending basewide attrition to permit assignment to permanent positions.

DOLLARS IN THOUSANDS

EXCLUSION CRITERION	EXCLUDED FUNCTION	ACCOUNT	NOTE	DEPOT ABBR SEQUENCE NO DEPOT RIC	OCALC 21 FH	OOALC 22 FC	SMALC 23 FF	SAALC 24 FP	WRALC 25 FL
Non-SDO	Installation Equip Mgt Office	1.9	a		2016	1342	1457	1273	1491
	Packaging & Mat Hdlg	1.35	b		494	318	461	553	528
	DOD Dog Center	1.9	c		-	-	-	839	-
	Special Weapons	1.9	d		-	-	-	852	-
Non-Comparable SDO	Stock Control	1.2x	e		4090	3791	3407	3620	3158
	Air Cargo Operations	1.4x	f		2541	1859	847	1540	1781
	Management/Facilities Services	1.9	g		1077	1753	1187	1253	1155
DODMDS Policy	Depot Support	Various	h		1769	1066	1626	1090	1564
	Ammo Storage	Various	i		-	2727	-	-	-
	Ammo Storage Contracts	1.9	j		-	9310	-	-	-
SCTC Policy	Bulk Fuel	1.141	k		816	924	1049	921	992
	Customer Service Store	1.142	l		125	189	113	206	395
	Passenger	1.32	l		62	49	48	65	27
	HHG	1.33	l		230	228	330	47	240
	Air Passenger	1.42	l		15	40	-	150	49
One-Time Expenses	Contractual Services	1.131/1.9	m		-	-	520	172	946
	Packing Supplies	1.9	n		-	-	324	-	589
	Administrative Reassignment	Various	o		-	-	-	2325	-
	Total				13235	23596	11369	14906	12293

Table 2-1-3. Air Force

D. MARINE CORPS DEPOTS

1. Costs of excluded functions do not include costs of installation overhead. Installation overhead charges for distribution at MCLSBLANT, Albany, and MCLSBPAC, Barstow, have been adjusted to reflect the effect of excluding the manyears and a limited range of facilities associated with the excluded functions.

2. Following notes describe the functions contained in Table 2-1-4, page 2.82.

a. Procurement Operations are reported in the 2000 series of NAVCOMPT accounts used for SDO by the two Marine Corps Logistics Support Bases (LSB). Costs for this function were excluded from depot costs because they are not part of SDO as prescribed in DODI 7220.17.

b. End item accessory components and collateral equipment costs at both Albany and Barstow were identified by HQS USMC/LPF-1. At Albany, the costs were shown against NAVCOMPT account 2135, Unit and Set Assembly. At Barstow the costs were reported against NAVCOMPT account 2133, Preservation and Packaging. These costs were excluded because the materiel and supplies were not consumed by the Materiel Division at either activity in performing the distribution mission.

c. MCLSBLANT serves as the single point for receipt, store and issue of classified and unclassified publications in support of the Marine Corps worldwide. HQ USMC letter, 23 April 1976, subject: Unique Service/Agency Needs, indicated this function should be considered unique. Therefore, both costs and associated workload were excluded from modeling analysis.

d. Differences in distribution structures and missions within DOD necessitated making a split of costs for Stock Control (DODI 7220.17 account 1.2x). The split required for comparability was between stock control costs related to receiving documentation versus all other stock control costs. The former costs are part of basic supply production while the latter costs are an admixture of individual service

prerogatives in organizational structure, data processing procedures, stock accountability, and customer service functions. The two Marine Corps LSBs were requested to segregate the portion of stock control charges for receiving documentation from all other stock control charges because these activities use the NAVCOMPT account structure for SDC which does not provide a separate account for receipt control processing. All other stock control charges were excluded as non-comparable.

e. Passenger Processing and Household Goods (HHG) functions were not considered by DODMDS to be an integral part of wholesale materiel distribution.

f. Customer Service Store (DODI account 1.142) was identified by DODMDS as a function outside the scope of wholesale materiel distribution for all depots. MCLSBPAC charged the NAVCOMPT account 2142 for customer service store functions, but also included charges associated with retail activity against the 2142 account. These other costs have been included in depot cost for Barstow.

DOLLARS IN THOUSANDS

Exclusion Criterion	Excluded Function	Account	Note	Depot ABBR Sequence No. Depot RIC	MCLSBLANT 26 MA	MCLSBPAC 27 MB
Non-SDO	Purchase Contract Administration	2700	a		269	328
	End Item Accessories and Collateral Equipment	2135	b		463	-
	Publications	2133				484
		Various	c		622	-
Non-Comparable SDO	Stock Control	22XX	d		671	329
SCTG Policy	Passenger Processing	2320	e		12	13
	HHG	2330	e		57	50
	Customer Service Store	2142	f		38	142
	Total				2132	1346

Table 2-1-4. Marine Corps

E. DEFENSE LOGISTICS AGENCY DEPOTS

1. Following notes pertain to excluded functions in Table 2-1-5, page 2-84.

a. Industrial Plant Equipment (IPE) is defined in DODI 7220.17 as transportation, maintenance, storage, repair and rebuild of inactive equipment, not included in Industrial Reserve Plants, being retained in anticipation of future requirements of defense production programs. Three DLA depots under study incur costs associated with IPE operations: DCSC, Columbus, OH; DDMP, Mechanicsburg, PA; and DDTC, Tracy, CA. The DODI requires costs associated with IPE operations to be reported within Program Element 780110 - Industrial Preparedness. Therefore, costs of IPE operations recorded against cost account P380, Storage, Maintenance and Repair of IPE, were excluded. In preparing installation overhead for DLA activities, HQ DLA excluded manpower and facilities costs for IPE operations in calculating installation services costs.

b. Costs associated with maintenance and repair of mission stocks and non-DLA items in depot maintenance shops at DDOU Ogden, UT and DGSC Richmond, VA were recorded against DLA account Code P364, Depot Maintenance Operations, and excluded. HQ DLA excluded installation services costs associated with this function as in 1.a. above.

c. HQ DLA identified Contractual Services in Storage, DLA account code P363, as one-time expenses at DCSC Columbus, OH and DESC Dayton, OH and excluded same.

d. Costs recorded in P362, Contractual Packing and Issue, at DGSC were excluded from depot costs as one-time expenses because they represent an Intra-DOD purchase of services. OSD Comptroller Memorandum, 29 April 1974, subject: Funding Responsibility for Intra-DOD Warehousing Services, stated that programmed warehousing services were to be funded on a common-service basis, thereby eliminating interservice reimbursements for these services.

DOLLARS IN THOUSANDS

Exclusion Criterion	Excluded Functions	Account	Note	Depot ABBR / Sequence No. / Depot RIC	DCSC 28 SC	DDMP 29 SA	DDMT 30 SM	DDOU 31 SU	DDTC 32 SB	DESC 33 SE	DGSC 34 SR
Non-SDO	Industrial Plant Equipment	380	a		2812	4365	-	-	3118	-	-
	Depot Maintenance Operations	364	b		-	-	-	1235	-	-	1276
One-Time Expenses	Contractual Storage	363	c		198	-	-	-	-	78	-
	Contractual Packing & Issue	362	d		-	-	-	-	-	-	226
	Total				3010	4365	-	1235	3118	78	1502

Table 2-1-5. DLA

EXHIBIT 2-2

Preservation and Packaging Costs for Naval Air Stations (NAS) and Marine Corps Air Station Cherry Point

1. Preservation and Packaging (P&P) is identified in DODI 7220.17 (Cost Account 1.133) as a Supply Depot Operations (SDO) function and is performed within the Supply Department or SDO activity at each of the DODMDS installations except the four NASs and MCAS Cherry Point. At these five installations, P&P is performed by the Naval Air Rework Facility (NARF) as a cost for repair of the applicable weapon system (no cost to SDO activity).

2. P&P is a significant operational function at most of the other 29 installations averaging $896,000 annually (11 percent of distribution handling and storage cost) and therefore cannot be dismissed as a Service prerogative.

3. NAS Alameda, NAS North Island and MCAS Cherry Point responded to the DODMDS Data Call (RCS DD-I&L (OT) 763), Page F-33.2 and provided a 32 day census of the NARF P&P effort reporting manhours worked and packages produced. NAS Norfolk provided manhour and workload data in conjunction with a 22 Sep TDY visit. No P&P input was provided by NASJAX. Materiels and supplies cost, a sizeable portion of the P&P cost, was not provided by any of the five depots. Wage rates were determined from applicable cost report data. NAS and MCAS NAVSUP PUB 295 workload data provided a basis for expressing P&P manhours and packages produced to total line items processed (shipments + receipts), and were utilized in developing P&P cost for NASJAX. Materiels and supplies cost were available in the Air Force Air Logistics Center P&P cost data and represented a fair application basis since the materiel preserved and packaged are aircraft related and similar to that handled at a NARF P&P function.

4. The matrix shown in Figure 2-2-1, page 2.87 displays the methodology for estimating the P&P cost by depot.

5. Using the estimated NAS and MCAS P&P cost, a validation of the estimate was conducted by combining the estimated cost with the packing and container assembly cost from NAS cost reports and comparing that total with the same combination of accounts for the five ALCs and Corpus Christi Army Depot. These activities were selected for comparison because their workloads are primarily aircraft related. The combination of accounts, rather than P&P alone, was used in order to overcome the procedural differences in collecting and reporting costs employed by the Services, especially in regard to the overlap of effort between P&P and packing accounts. The weighted average of the summation of the NASs and MCAS cost elements to line items processed (shipments + receipts) is equal to $1.91. This compares with a weighted average of $1.65 for the five ALCs and Corpus Christi Army Depot, which also handle aircraft related items. In view of the weighted average cost similarity, the study group concluded that derived P&P costs for NAS and MCAS were comparable.

6. Installation overhead, i.e., utilities, other facility engineering support and management services, costs in support of SDO were increased by a ratio of P&P manyears over total applicable installation population.

Figure 2-2-1. Preservation and Packaging Costs Naval Air Stations (NAS) and Marine Corps Air Station Cherry Point (Actual Dollars)

	NAS Alameda	NAS N. Island	NAS Jacksonville	*NAS. Norfolk	MCAS Cherry Pt
Annual Productive Manhours (based on 32 day census from Data Call or special request)	59840	91866	None Reported	74760	52765
Productive MH (Based on weighted average of P&P MH to PUB 295 Rpt line items processed-shipments + receipts)			73,698		
SDO Average Civilian Wage Rate (Based on handling & storage accounts)	$8.05	$7.28	$5.77	$5.91	$6.27
P&P Labor Cost (MH x Wage Rate)	481,712	668,784	425,237	441,832	330,837
Total Packages Produced (Based on 32 day census from Data Call or special request)	109,993	145,784	None Reported	80,024	32,614
Pkgs. Produced (Based on weighted average of pkgs produced to PUB 295 Report line items processed)			97,053		
Materiels & Supplies (MS) Cost (Pkgs. produced x $0.31-weighted MS cost per pkg. produced for 5 ALC's)	$34,098	$45,193	$30,086	$24,807	$10,110
Total P & P Cost (Labor + MS)	$515,810	$713,977	$455,323	$466,639	$340,947**

* NAS Norfolk Supply Department and NARF provided P&P manhour and workload data at special request for DODMDS P&P cost derivation

** Does not include $37K in P&P performed by Supply Department

EXHIBIT 2-3

Installation Services Cost

1. The data in Exhibit 2-3 are organized as follows:

a. Column 1 contains the installation service functional areas described in Part B.

b. Column 2 shows the accounting report source and the total expenses by function as of 30 June 1975.

c. Column 3 contains the allocated share of installation service costs derived by the Services and DLA in response to the DODMDS Data Call, RCS: DD-I&L(OT)763. The correspondence is referenced in Appendix C.7 of Chapter 3. These data are shown under Supply Overhead in Appendix C.7 and are the basis for fixed costs used in modeling analysis.

d. Column 4 contains the allocated share of installation service costs derived by DODMDS using revised population ratios and the procedures described in Part B, paragraph 9.

2. In order to more closely match functions across Service/Agency lines, the following migrations were accomplished:

a. The allocated costs of the manpower requirements, production planning, management engineering, and work measurement functions performed by installation level organizations at NSCs and DLA depots/centers were migrated to Supply Support costs for analysis.

b. Costs related to maintaining materiel handling systems, which were charged to DODI 7220.17 account code 1.9 at ALCs, were migrated to Supply Overhead costs for analysis.

3. The following population data were employed in computing the DODMDS derived installation services costs (Col. 4):

Population Data

Depot #	Depot	SDO Pers. (Mil + Civ)	Applicable Installation Pers. (Mil + Civ)	SDO Pop To Total Pop
1	ANAD Anniston	779	4892	.16
2	CCAD Corpus Christi	295	4341	.07
3	LEAD Letterkenny	869	5839	.15
4	LBAD Lexington	584	4143	.14
5	NCAD New Cumberland	928	4192	.22
6	PUAD Pueblo	299	2495	.12
7	RRAD Red River	1315	5767	.23
8	SAAD Sacramento	929	3195	.29
9	SHAD Sharpe	590	2041	.29
10	TOAD Tobyhanna	594	3447	.17
11	TEAD Tooele	782	4784	.16
12	NAS Alameda	476	2378	.20
13	NAS Jacksonville	393	6837	.057
14	NAS Norfolk	434	7225	.06
15	NAS North Island	421	13074	.032
16	NSC Norfolk	1306	3184	.41
17	NSC Oakland	956	2094	.46
18	NSC Pearl Harbor	223	788	.28
19	NSC San Diego	394	948	.42
20	MCAS Cherry Pt	339	10738	.03
21	Oklahoma City ALC	1663	22230	.07
22	Ogden ALC	1301	17664	.07
23	Sacramento ALC	1373	17720	.08
24	San Antonio ALC	1975	27159	.07
25	Warner Robins ALC	1489	19122	.08
26	MCLSBLANT	428	816	.53
27	MCLSBPAC	684	1927	.355
28	DCSC Columbus	1101	4169	.24
29	DDMP Mechanics	1047	1536	.68
30	DDMT Memphis	1596	2416	.66
31	DDOU Ogden	1416	2180	.65
32	DDTC Tracy	1110	1835	.60
33	DESC Dayton	605	3090	.20
34	DGSC Richmond	787	2774	.28

Note: (Next Page)

Note: Figures in the column labelled Applicable Installation Personnel (Military and Civilian) do not include activities supported on a reimbursable basis by NAS's, MCASCP, MCLSBs and DLA depots/centers. Major activities supported on a reimbursable basis by these installations include Defense Property Disposal Regions (DPDR) and Naval Air Rework Facilities (NARF). Applicable Installation Personnel figures for DLA depots/centers were reported erroneously by HQ DLA. For computation of DODMDS derived installation service costs for sensitivity analysis, corrected figures were used. The major difference was that DLA did not include the population changed to P900 accounts as part of the total installation personnel requested in the DODMDS Data Call.

ANNISTON ARMY DEPOT (1)
($ Thousands)

(1) INSTALLATION SERVICE	(2) AMCCP-159 PART C [1]	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair	2,618	629	629
Utilities	2,314	382	370
Minor Construction	351	45	45
Other Engineering	1,323	292	212
SUBTOTAL	6,606	1,348	1,256
MANAGEMENT			
Command & Staff	3,613	817	582
Communications [2]	-	-	-
Security	1,431	228	229
Printing & Reproduction [3]	-	-	-
Equipment Management	987	202	158
SUBTOTAL	6,031	1,247	965
TRANSPORTATION	624	698 [4]	508
AUTOMATED DATA PROCESS	2,360	889	889
TOTAL	15,621	4,182	3,618

[1] AMC Resource Management Report, Part C, Section 1, Base Operations Functions as of 30 June 1975.
[2] No charges
[3] Included in Command & Staff.
[4] Transcription error. A small portion of this value belongs under Management rather than Transportation.

CORPUS CHRISTI (2)
($ Thousands)

(1) INSTALLATION SERVICE	(2) AMCCP-159[1] PART C	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair	1,023	222	222
Utilities	2,377	455	166
Minor Construction	162	92	92
Other Engineering	762	198	53
SUBTOTAL	4,324	967	533
MANAGEMENT			
Command & Staff	4,121	406	288
Communications[2]	-	-	-
Security	547	36	38
Printing & Reproduction[3]	-	-	-
Equipment Management	1,750	138	123
SUBTOTAL	6,418	580	449
TRANSPORTATION	125	28	28
AUTOMATED DATA PROCESS	2,499	611	611
TOTAL	13,366	2,186	1,621

[1] AMC Resource Management Report, Part C, Section 1, Base Operations Functions as of 30 June 1975.
[2] No charges.
[3] Included in Command & Staff.

LETTERKENNY ARMY DEPOT (3)
($ Thousands)

(1) INSTALLATION SERVICE	(2) AMCCP-159 PART C [1]	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair	2,845	964	964
Utilities	2,861	541	429
Minor Construction	508	119	119
Other Engineering	2,515	197	377
SUBTOTAL	8,729	1,821	1,889
MANAGEMENT			
Command & Staff	4,210	819	631
Communications [2]	-	-	-
Security	1,092	201	164
Printing & Reproduction [3]	-	-	-
Equipment Management	1,165	250	175
SUBTOTAL	6,467	1,270	970
TRANSPORTATION	1,106	490	490
AUTOMATED DATA PROCESS	3,575	858	858
TOTAL	19,877	4,439	4,207

[1] AMC Resource Management Report, Part C, Section 1, Base Operations Functions as of 30 June 1975.
[2] No charges.
[3] Included in Command & Staff.

LEXINGTON-BLUE GRASS ARMY DEPOT ACTIVITY (4)
($ Thousands)

(1) INSTALLATION SERVICE	(2) AMCCP-159 PART C[1]	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair	1,524	494	494
Utilities	1,622	287	227
Minor Construction	625	7	7
Other Engineering	1,606	295	225
SUBTOTAL	5,377	1,083	953
MANAGEMENT			
Command & Staff	3,797	877	531
Communications[2]	-	-	-
Security	1,468	258	206
Printing & Reproduction[3]	-	-	-
Equipment Management	838	128	117
SUBTOTAL	6,103	1,263	854
TRANSPORTATION	844	285	285
AUTOMATED DATA PROCESS	2,184	723	723
TOTAL	14,508	3,354	2,815

[1] AMC Resources Management Report, Part C, Section 1, Base Operations Functions as of 30 June 1975.
[2] No charges.
[3] Included in Command & Staff.

NEW CUMBERLAND ARMY DEPOT (5)
($ Thousands)

(1) INSTALLATION SERVICE	(2) AMCCP-159 PART C [1]	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair	1,825	642	642
Utilities	2,176	598	479
Minor Construction	340	183	183
Other Engineering	1,416	355	312
SUBTOTAL	5,757	1,778	1,616
MANAGEMENT			
Command & Staff	3,356	1,281	739
Communications [2]	-	-	-
Security	579	136	127
Printing & Reproduction [3]	-	-	-
Equipment Management	1,141	524	251
SUBTOTAL	5,076	1,941	1,117
TRANSPORTATION	398	286	286
AUTOMATED DATA PROCESS	4,836	1,163	1,163
TOTAL	16,067	5,168	4,182

[1] AMC Resource Management Report, Part C, Section 1, Base Operations Functions as of 30 June 1975.
[2] No charges.
[3] Included in Command & Staff.

PUEBLO DEPOT ACTIVITY (6)
($ Thousands)

(1) INSTALLATION SERVICE	(2) AMCCP-159 PART C [1]	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair	1,723	147	147
Utilities	1,481	258	178
Minor Construction	59	6	6
Other Engineering	1,727	257	207
SUBTOTAL	4,990	668	538
MANAGEMENT			
Command & Staff	2,890	575	347
Communications [2]	-	-	-
Security	1,662	435	199
Printing & Reproduction [3]	-	-	-
Equipment Management	1,313	277	158
SUBTOTAL	5,865	1,287	704
TRANSPORTATION	1,104	367	367
AUTOMATED DATA PROCESS	2,045	626	626
TOTAL	14,004	2,948	2,235

[1] AMC Resources Management Report, Part C, Section 1, Base Operations Functions as of 30 June 1975.
[2] No charges.
[3] Included in Command & Staff.

RED RIVER ARMY DEPOT (7)
($ Thousands)

(1) INSTALLATION SERVICE	(2) AMCCP-159 PART C [1]	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair	3,411	528	528
Utilities	2,390	499	550
Minor Construction	484	68	68
Other Engineering	2,231	578	513
SUBTOTAL	8,516	1,674	1,659
MANAGEMENT			
Command & Staff	4,577	2,051	1,052
Communications [2]	-	-	-
Security	1,072	327	247
Printing & Reproduction [3]	-	-	-
Equipment Management	1,599	446	368
SUBTOTAL	7,248	2,824	1,667
TRANSPORTATION	855	714	714
AUTOMATED DATA PROCESS	3,539	1,800	1,800
TOTAL	20,158	7,012	5,840

[1] AMC Resources Management Report, Part C, Section 1, Base Operations Functions as of 30 June 1975.
[2] No charges.
[3] Included in Command & Staff.

SACRAMENTO ARMY DEPOT (8)
($ Thousands)

(1) INSTALLATION SERVICE	(2) AMCCP-159 PART C[1]	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair	1,226	586	586
Utilities	780	289	226
Minor Construction	295	94	94
Other Engineering	810	256	235
SUBTOTAL	3,111	1,225	1,141
MANAGEMENT			
Command & Staff	3,427	1,421	994
Communications[2]	-	-	-
Security	621	201	180
Printing & Reproduction[3]	-	-	-
Equipment Management	1,323	509	384
SUBTOTAL	5,371	2,131	1,558
TRANSPORTATION	388	250	250
AUTOMATED DATA PROCESS	3,928	1,584	1,584
TOTAL	12,798	5,190	4,533

[1] AMC Resource Management Report, Part C, Section 1, Base Operations Functions as of 30 June 1975.
[2] No charges.
[3] Included in Command & Staff.

SHARPE ARMY DEPOT (9)
($ Thousands)

(1) INSTALLATION SERVICE	(2) AMCCP-159 PART C[1]	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair	896	230	230
Utilities	614	249	178
Minor Construction	84	23	23
Other Engineering	873	305	253
SUBTOTAL	2,467	807	684
MANAGEMENT			
Command & Staff	2,940	1,170	853
Communications[2]	-	-	-
Security	552	259	160
Printing & Reproduction[3]	-	-	-
Equipment Management	1,179	555	342
SUBTOTAL	4,671	1,984	1,355
TRANSPORTATION	358	68	68
AUTOMATED DATA PROCESS	1,153	966	966
TOTAL	8,649	3,825	3,073

[1]AMC Resource Management Report, Part C, Section 1, Base Operations Functions as of 30 June 1975.
[2]No charges.
[3]Included in Command & Staff.

TOBYHANNA ARMY DEPOT (10)
($ Thousands)

(1) INSTALLATION SERVICE	(2) AMCCP-159 PART C [1]	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair	1,785	1,012	1,012
Utilities	1,617	820	273
Minor Construction	258	4	4
Other Engineering	967	248	164
SUBTOTAL	4,627	2,084	1,453
MANAGEMENT			
Command & Staff	3,156	1,146	536
Communications [2]	-	-	-
Security	611	-	104
Printing & Reproduction [3]	-	-	-
Equipment Management	728	186	124
SUBTOTAL	4,495	1,332	764
TRANSPORTATION	274	291	158
AUTOMATED DATA PROCESS	3,413	1,547	1,547
TOTAL	12,809	5,254	3,922

[1] AMC Resource Management Report, Part C, Section 1, Base Operations Functions as of 30 June 1975.
[2] No charges.
[3] Included in Command & Staff.

TOOELE ARMY DEPOT (11)
($ Thousands)

(1) INSTALLATION SERVICE	(2) AMCCP-159 PART C [1]	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair	2,245	706	706
Utilities	2,058	507	329
Minor Construction	669	15	15
Other Engineering	1,604	385	257
SUBTOTAL	6,576	1,613	1,307
MANAGEMENT			
Command & Staff	4,173	1,037	668
Communications [2]	-	-	-
Security	2,631	1,201	421
Printing & Reproduction [3]	-	-	-
Equipment Management	1,579	367	252
SUBTOTAL	8,383	2,605	1,341
TRANSPORTATION	1,245	632	632
AUTOMATED DATA PROCESS	2,732	1,157	1,157
TOTAL	18,936	6,007	4,437

[1] AMC Resource Management Report, Part C, Section 1, Base Operations Functions as of 30 June 1975.
[2] No charges.
[3] Included in Comman_ & Staff.

NAS ALAMEDA (12)
($ Thousands)

(1) INSTALLATION SERVICE	(2) NAVCOMPT[1] FORM 2168	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair	1,137	142	22
Utilities	567	113	113
Minor Construction	182	-0-	-0-
Other Engineering	2,293	459	630
SUBTOTAL	4,179	714	765
MANAGEMENT			
Command & Staff	2,059	495	412
Communications	313	31	63
Security	709	71	142
Printing & Reproduction	396	92	79
Equipment Management	131	31	26
SUBTOTAL	3,608	720	722
TRANSPORTATION	505	314	314
AUTOMATED DATA PROCESS	1,694	883	883
TOTAL	10,637	2,631	2,684

[1] NAVCOMPT Form 2168, Operating Budget Expense Report as of 30 June 1975.

NAS JACKSONVILLE (13)
($ Thousands)

(1) INSTALLATION SERVICE	(2) NAVCOMPT[1] FORM 2168	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair	3,620	166	255
Utilities	1,664	95	95
Minor Construction	60	-0-	-0-
Other Engineering	2,259	129	129
SUBTOTAL	7,603	390	479
MANAGEMENT			
Command & Staff	1,889	217	107
Communications	589	34	34
Security	546	31	31
Printing & Reproduction	224	35	13
Equipment Management	97	6	6
SUBTOTAL	3,345	323	191
TRANSPORTATION	1,503	182	182
AUTOMATED DATA PROCESS	1,239	765	765
TOTAL	13,690	1,660	1,617

[1] NAVCOMPT Form 2168, Operating Budget Expense Report as of 30 June 1975.

NAS NORFOLK (14)
($ Thousands)

(1) INSTALLATION SERVICE	(2) NAVCOMPT[1] FORM 2168	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair	1,609	442	185
Utilities	2,444	147	147
Minor Construction	19	5	5
Other Engineering	1,633	90	98 8[2]
SUBTOTAL	5,705	684	443
MANAGEMENT			
Command & Staff	2,015	348	121
Communications	331	20	20
Security	551	28	33
Printing & Reproduction	180	38	11
Equipment Management	188	39	11
SUBTOTAL	3,265	473	196
TRANSPORTATION	738	156	156
AUTOMATED DATA PROCESS	551	360	360
TOTAL	10,259	1,674	1,145

[1] NAVCOMPT Form 2168, Operating Budget Expense Report as of 30 June 1975.

[2] Estimated fire protection service provided by Naval Station Norfolk.

NAS NORTH ISLAND (15)
($ Thousands)

(1) INSTALLATION SERVICE	(2) NAVCOMPT[1] FORM 2168	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair	2,446	835	137
Utilities	1,366	44	44
Minor Construction	80	36	36
Other Engineering	3,547	114	114
SUBTOTAL	7,439	1,029	331
MANAGEMENT			
Command & Staff	3,478	247	112
Communications	951	27	31
Security	832	27	27
Printing & Reproduction	291	34	9
Equipment Management	501	16	16
SUBTOTAL	6,053	351	195
TRANSPORTATION	1,821	188	188
AUTOMATED DATA PROCESS	-0-	723	723
TOTAL	15,313	2,291	1,437

[1] NAVCOMPT Form 2168, Operating Budget Expense Report as of 30 June 1975.

NSC NORFOLK (16)
($ Thousands)

(1) INSTALLATION SERVICE	(2) ACTY MGT[1] RPT (AMR)	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair	2,344	2,049	821
Utilities	2,284	1,096	936
Minor Construction	31	31	31
Other Engineering	1,183	568	1,021
SUBTOTAL	5,842	3,744	2,809
MANAGEMENT			
Command & Staff	3,983	1,562	1,633
IBOO[2]	(1,035)	(507)	(424)
Communications	791	377	324
Security	717	377	294
Printing & Reproduction	733	285	301
Equipment Management	584	352	239
SUBTOTAL	6,808	2,913	2,792
TRANSPORTATION	1,300	1,039	1,039
AUTOMATED DATA PROCESS	3,597	575	575
TOTAL	17,547	8,271	7,215

[1] Activity Management Report as of 30 June 1975.
[2] See prefatory note 2a, page 2.88.

NSC OAKLAND (1?)
($ Thousands)

(?) INSTALLATION SERVICE	(1) ACTY MGT[1] RPT (AMR)	(2) REPORTED SHARE	(3) DODMIS
[illegible]			
Maintenance & Repair	993	794	373
Utilities	927	577	427
Minor Construction	46	46	[illegible]
Other Engineering	1,065	656	729
SUBTOTAL	3,031	2,073	1,575
MANAGEMENT			
Command & Staff	4,280	2,132	1,956
IBOO[2]	(700)	(473)	(365)
Communications	344	209	157
Security	1,068	663	489
Printing & Reproduction	692	311	316
Equipment Management	504	378	230
SUBTOTAL	6,888	3,693	3,148
TRANSPORTATION	1,556	1,277	1,277
AUTOMATED DATA PROCESS	3,039	1,519	1,519
TOTAL	14,584	8,562	7,519

[1] Activity Management Report as of 30 June 1975.
[2] See prefatory note 2a, page 2.88.

(1) INSTALLATION SERVICE	(2) ACT MGT RPT (AMR)[1]	(3) REPORTED SHARE	(4) RODMDS[3]
FACILITY			
Maintenance & Repair	820	469	No Change
Utilities	584	193	
Minor Construction	35	35	
Other Engineering	256	84	
SUBTOTAL	1,695	781	
MANAGEMENT			
Command & Staff	1,125	371	
IBOO[2]	(435)	(152)	
Communications	126	41	
Security	14	5	
Printing & Reproduction	187	49	
Equipment Management	50	27	
Military Variances	-	-	
SUBTOTAL	1,502	495	
TRANSPORTATION	456	285	
AUTOMATED DATA PROCESS	1,398	530	
TOTAL	6,988	2,095	

[1] Activity Management Report as of 30 June 197[illegible].
[2] See prefatory note 1a, page 2.8a.
[3] Unchanged from reported share due to small proportion of wholesale activity.

NSC SAN DIEGO (19)
($ Thousands)

(1) INSTALLATION SERVICE	(2) ACTY MGT[1] RPT (AMR)	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair	914	519	226
Utilities	370	189	154
Minor Construction	1	1	1
Other Engineering	421	213	403
SUBTOTAL	1,706	923	784
MANAGEMENT			
Command & Staff	2,249	788	936
IBOO[2]	(186)	(97)	(77)
Communications	214	107	89
Security	215	108	90
Printing & Reproduction	236	103	98
Equipment Management	97	73	40
Military Variances	-	-	-
SUBTOTAL	3,011	1,180	1,253
TRANSPORTATION	953	538	538
AUTOMATED DATA PROCESS	1,609	728	728
TOTAL	7,279	3,369	3,303

[1] Activity Management Report as of 30 June 1975.
[2] See prefatory note 2a, page 2.88.

MCAS CHERRY POINT (20)
($ Thousands)

(1) INSTALLATION SERVICE	(2) NAVCOMPT[1] FORM 2168	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair	3,593	559	62
Utilities	2,051	65	66
Minor Construction	142	26	26
Other Engineering	1,696	54	167
SUBTOTAL	7,481	804	321
MANAGEMENT			
Command & Staff	2,465	349	78
Communications	833	26	27
Security	284	9	9
Printing & Reproduction	51	7	2
Equipment Management	390	55	12
Military Variances	1,235	173	40
SUBTOTAL	5,258	619	168
TRANSPORTATION	1,316	148	148
AUTOMATED DATA PROCESS	1,706	707	707
TOTAL	15,761	2,278	1,344

[1] NAVCOMPT Form 2168, Operating Budget Expense Report as of 30 June 1975.

OKLAHOMA CITY ALC (21)
($ Thousands)

(1) INSTALLATION SERVICE	(2) See Notes	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair[1]	8,885	756	1,052
Utilities[1]	5,066	379	379
Minor Construction[1]	1,533	35	35
Other Engineering[1]	5,193	334	388
DSFF[2]	979	627	627
SUBTOTAL	21,656	2,131	2,481
MANAGEMENT			
Command & Staff[3]	11,613	869	869
Communications[3]	976	73	73
Security[3]	1,943	145	145
Printing & Reproduction[3]	2,240	167	167
Equipment Management[4]	2,016	151	151
Procurement & Misc.[3]	1,417	-[5]	106
SUBTOTAL	20,205	1,405	1,511
TRANSPORTATION[6]	2,242	373	373
AUTOMATED DATA PROCESS[7]	10,199	943	943
TOTAL	54,302	4,852	5,308

[1] RCS: HAF-PRE(SA)7101.
[2] See prefatory note 2b, page 2.88.
[3] RCS: DDI&L(OT)763.
[4] RCS: LOG-ACF(Q)7106.
[5] Data reported were not used in original computation of management costs because of non-comparability. See Part B, paragraph 8.6.1.
[6] RC Manager Report (PCN 370543) as of 30 Jun 76.
[7] Provided by AFLC/LOMX.

OGDEN ALC (22)
($ Thousands)

(1) INSTALLATION SERVICE	(2) See Notes	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair[1]	10,342	780	1,161
Utilities[1]	3,820	115	115
Minor Construction[1]	1,828	281	281
Other Engineering[1]	5,816	376	428
DSFF[2]	889	480	480
SUBTOTAL	22,695	2,032	2,465
MANAGEMENT			
Command & Staff[3]	10,599	780	780
Communications[3]	352	26	26
Security[3]	1,775	131	131
Printing & Reproduction[3]	1,331	98	98
Equipment Management[4]	1,341	99	99
Procurement & Misc.[3]	1,104	-[5]	81
SUBTOTAL	16,502	1,134	1,215
TRANSPORTATION[6]	3,343	395	395
AUTOMATED DATA PROCESS[7]	9,763	653	653
TOTAL	52,303	4,214	4,728

[1] RCS: HAF-PRE(SA)7101.
[2] See prefatory note 2b, page 2.88.
[3] RCS: DDI&L(OT)763.
[4] RCS: LOG-ACF(Q)7106.
[5] Data reported were not used in original computation of management costs because of non-comparability. See Part B, paragraph 8.6.1.
[6] RC Manager Report (PCN 370543) as of 30 Jun 75.
[7] Provided by AFLC/LOMX.

SACRAMENTO ALC (23)
($ Thousands)

(1) INSTALLATION SERVICE	(2) See Notes	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair[1]	6,661	492	690
Utilities[1]	3,469	269	269
Minor Construction[1]	743	18	18
Other Engineering[1]	5,297	356	411
DSFF[2]	720	468	468
SUBTOTAL	16,890	1,603	1,856
MANAGEMENT			
Command & Staff[3]	11,462	888	888
Communications[3]	1,319	102	102
Security[3]	1,781	138	138
Printing & Reproduction[3]	3,130	243	243
Equipment Management[4]	1,457	113	113
Procurement & Misc.[3]	1,385	-[5]	107
SUBTOTAL	20,534	1,484	1,591
TRANSPORTATION[6]	2,764	356	356
AUTOMATED DATA PROCESS[6]	9,617	606	606
TOTAL	49,805	4,049	4,409

[1]RCS: HAF-PRE(SA)7101.
[2]See prefatory note 2b, page 2.88.
[3]RCS: DDI&L(OT)763.
[4]RCS: LOG-ACF(Q)7106.
[5]Data reported were not used in original computation of management costs because of noncomparability. See Part B, paragraph 8.6.1.
[6]Provided by AFLC/LOMX.

SAN ANTONIO ALC (24)
($ Thousands)

(1) INSTALLATION SERVICE	(2) See Notes	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair[1]	8,726	451	700
Utilities[1]	6,217	452	452
Minor Construction[1]	1,162	57	57
Other Engineering[1]	7,119	448	517
DSFF[2]	990	654	654
SUBTOTAL	24,214	2,062	2,380
MANAGEMENT			
Command & Staff[3]	13,493	981	981
Communications[3]	400	29	29
Security[3]	2,446	178	178
Printing & Reproduction[3]	2,233	162	162
Equipment Management[4]	1,273	93	93
Procurement & Misc.[3]	1,163	-[5]	85
SUBTOTAL	21,008	1,442	1,527
TRANSPORTATION[6]	3,175	391	391
AUTOMATED DATA PROCESS[6]	10,423	803	803
TOTAL	58,820	4,698	5,101

[1]RCS: HAF-PRE(SA)7101.
[2]See prefatory note 2b, page 2.88.
[3]RCS: DDI&L(OT)763.
[4]RCS: LOG-ACF(Q)7106.
[5]Data reported were not used in original computation of management costs because of noncomparability. See Part B, paragraph 8.6.1.
[6]Provided by AFLC/LOMX.

WARNER ROBINS ALC (25)
($ Thousands)

(1) INSTALLATION SERVICE	(2) See Notes	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair[1]	5,982	609	812
Utilities[1]	5,054	392	392
Minor Construction[1]	963	167	167
Other Engineering[1]	5,069	345	393
DSFF[2]	322	216	216
SUBTOTAL	17,390	1,729	1,980
MANAGEMENT			
Command & Staff[3]	11,480	890	890
Communications[3]	1,318	102	102
Security[3]	1,610	125	125
Printing & Reproduction[3]	2,528	195	195
Equipment Management[4]	1,491	116	116
Procurement & Misc.[3]	1,390	-[5]	108
SUBTOTAL	19,817	1,428	1,536
TRANSPORTATION[6]	2,924	351	351
AUTOMATED DATA PROCESS[6]	7,845	633	633
TOTAL	47,976	4,141	4,500

[1]RCS: HAF-PRE(SA)7101.
[2]See prefatory note 2b, page 2.88.
[3]RCS: DDI&L(OT)763.
[4]RCS: LOG-ACF(Q)7106.
[5]Data reported were not used in original computation of management costs because of noncomparability. See Part B, paragraph 8.6.1.
[6]Provided by AFLC/LOMX.

MCLSB ALBANY (26)
($ Thousands)

(1) INSTALLATION SERVICE	(2) NAVCOMPT[1] FORM 2168	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair	2,036	1,494	1,386
Utilities	534	280	280
Minor Construction	83	56	56
Other Engineering	894	469	469
SUBTOTAL	3,547	2,299	2,191
MANAGEMENT			
Command & Staff	3,775	1,205	1,982
Communications	392	122	206
Security	1,076	299	565
Printing & Reproduction	217	68	114
Equipment Management	216	91	113
SUBTOTAL	5,676	1,785	2,980
TRANSPORTATION	1,013	856	856
AUTOMATED DATA PROCESS	1,290	735	735
TOTAL	11,526	5,675	6,762

[1] NAVCOMPT Form 2168, Operating Budget Expense Report as of 30 June 1975.

MCLSB BARSTOW (27)
($ Thousands)

(1) INSTALLATION SERVICE	(2) NAVCOMPT[1] Form 2168	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair	2,524	1,802	1,289
Utilities	1,079	364	383
Minor Construction	58	38	38
Other Engineering	2,358	765	837
SUBTOTAL	6,019	2,969	2,547
MANAGEMENT			
Command & Staff	3,242	791	1,151
Communications	413	132	147
Security	747	184	265
Printing & Reproduction	411	118	146
Equipment Management	322	114	114
SUBTOTAL	5,135	1,339	1,823
TRANSPORTATION	2,261	763	763
AUTOMATED DATA PROCESS	948	719	719
TOTAL	14,363	5,790	5,852

[1]NAVCOMPT Form 2168, Operating Budget Expense Report as of 30 June 1975.

DCSC COLUMBUS (28)
($ Thousands)

(1) INSTALLATION SERVICE	(2) RCS - 48[1]	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair	2,683	2,282	1,619
Utilities	1,224	490	294
Minor Construction	258	219	219
Other Engineering	1,030	206	247
SUBTOTAL	5,195	3,197	2,379
MANAGEMENT			
Command & Staff	7,081	2,558	1,699
915/916[2]	(1,870)	(542)	(449)
Communications	1,160	70	278
Security	528	414	127
Printing & Reproduction	603	60	145
Equipment Management	1,012	703	243
SUBTOTAL	10,384	3,805	2,492
TRANSPORTATION	498	225	225
AUTOMATED DATA PROCESS	5,070	1,825	1,825
TOTAL	21,147	9,052	6,921

[1] DLA(M)48(C), Expense/Cost Report as of 30 June 1975.

[2] See prefatory note 2a, page 2.88.

DDMP MECHANICSBURG (29)
($ Thousands)

(1) INSTALLATION SERVICE	(2) RCS - 48[1]	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair	48	48	33
Utilities	1,197	958	814
Minor Construction	100	99	90
Other Engineering	217	163	148
SUBTOTAL	1,562	1,268	1,085
MANAGEMENT			
Command & Staff	1,788	1,479	1,216
915/916[2]	(501)	(402)	(341)
Communications	48	38	33
Security	22	18	15
Printing & Reproduction	28	25	19
Equipment Management	526	473	358
SUBTOTAL	2,412	2,033	1,641
TRANSPORTATION	332	227	227
AUTOMATED DATA PROCESS	989	892	892
TOTAL	5,295	4,420	3,845

[1] DLA(M)48(C). Expense/Cost Report as of 30 June 1975

[2] See prefatory note 2a, page 2.88.

DDMT MEMPHIS (30)
($ Thousands)

(1) INSTALLATION SERVICE	(2) RCS - 48[1]	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair	1,252	1,051	931
Utilities	337	169	222
Minor Construction	114	96	96
Other Engineering	293	220	193
SUBTOTAL	1,996	1,536	1,442
MANAGEMENT			
Command & Staff	2,633	2,314	1,737
915/916[2]	(648)	(565)	(428)
Communications	461	346	306
Security	505	404	333
Printing & Reproduction	96	86	63
Equipment Management	913	815	603
SUBTOTAL	4,608	3,965	3,041
TRANSPORTATION	485	353	353
AUTOMATED DATA PROCESS	1,691	1,225	1,225
TOTAL	8,780	7,079	6,061

[1] DLA(M)48(C), Expense/Cost Report as of 30 June 1975

[2] See prefatory note 2a, page 2.88.

DDOU OGDEN (31)
($ Thousands)

(1) INSTALLATION SERVICE	(2) RCS - 48[1]	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair	1,612	1,355	1,270
Utilities	672	504	437
Minor Construction	111	95	93
Other Engineering	575	431	373
SUBTOTAL	2,970	2,383	2,173
MANAGEMENT			
Command & Staff	2,821	2,523	1,833
915/916[2]	(498)	(442)	(324)
Communications	307	230	200
Security	499	400	324
Printing & Reproduction	31	28	20
Equipment Management	1,123	990	730
SUBTOTAL	4,781	4,171	3,107
TRANSPORTATION	443	301	301
AUTOMATED DATA PROCESS	1,699	1,692	1,692
TOTAL	9,893	8,547	7,273

[1] DLA(M)48(C), Expense/Cost Report as of 30 June 1975

[2] See prefatory note 2a, page 2.88.

DDTC TRACY (32)
($ Thousands)

(1) INSTALLATION SERVICE	(2) RCS - 48[1]	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair	1,021	970	816
Utilities	181	145	109
Minor Construction	78	74	74
Other Engineering	867	650	520
SUBTOTAL	2,147	1,839	1,519
MANAGEMENT			
Command & Staff	2,657	2,325	1,594
915/916[2]	(599)	(515)	(360)
Communications	267	230	160
Security	480	385	288
Printing & Reproduction	117	105	70
Equipment Management	920	828	552
SUBTOTAL	4,441	3,873	2,664
TRANSPORTATION	586	412	412
AUTOMATED DATA PROCESS	1,224	1,140	1,140
TOTAL	8,393	7,264	5,735

[1] DLA(M)48(C), Expense/Cost Report as of 30 June 1975.
[2] See prefatory note 2a, page 2.88.

DESC DAYTON (33)
($ Thousands)

(1) INSTALLATION SERVICE	(2) RCS - 48[1]	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair	1,292	932	552
Utilities	988	395	198
Minor Construction	139	100	100
Other Engineering	859	172	172
SUBTOTAL	3,278	1,599	1,022
MANAGEMENT			
Command & Staff	5,856	1,912	1,172
915/916[2]	(1,882)	(508)	(376)
Communications	822	74	164
Security	464	371	93
Printing & Reproduction	365	37	73
Equipment Management	478	282	96
SUBTOTAL	7,985	2,676	1,598
TRANSPORTATION	220	109	109
AUTOMATED DATA PROCESS	5,185	1,258	1,258
TOTAL	16,668	5,642	3,987

[1] DLA(M)48(C), Expense/Cost Report as of 30 June 1975

[2] See prefatory note 2a, page 2.88.

DGSC RICHMOND (34)
($ Thousands)

(1) INSTALLATION SERVICE	(2) RCS - 48[1]	(3) REPORTED SHARE	(4) DODMDS
FACILITY			
Maintenance & Repair	1,311	996	796
Utilities	778	311	218
Minor Construction	92	70	70
Other Engineering	687	137	192
SUBTOTAL	2,868	1,514	1,276
MANAGEMENT			
Command & Staff	4,880	2,122	1,366
915/916[2]	(1,192)	(477)	(334)
Communications	839	59	235
Security	491	392	137
Printing & Reproduction	498	50	139
Equipment Management	785	583	217
SUBTOTAL	7,483	3,206	2,094
TRANSPORTATION	385	211	211
AUTOMATED DATA PROCESS	3,871	894	894
TOTAL	14,617	5,825	4,475

[1]DLA(M)48(C), Expense/Cost Report as of 30 June 1975.

[2]See prefatory note 2a, page 2.88.

SECTION 3
NOMINAL DEPOT COSTING

A. INTRODUCTION

Baseline depot costs in conjunction with transportation costs provide a means for predicting the impact of realignment of distribution workload on the system costs associated with materiel distribution in DOD. In an optimization process, depot-commodity assignments and transportation links may vary from history when using baseline depot cost data. Internal depot materiel processing, however, is assumed to remain unchanged. This section describes the analytical step of evaluating potential system cost savings determined through capital investments, in both materiels handling equipment and warehouse space, to improve internal depot materiel processing.

Nominal or conceptual depot costs provide an insight into depot variable costs which could be expected if building construction and equipment funds were available to completely replace the basic depot materiels handling functions. Nominal depot operating and investment costs are defined as those costs associated with cost effective application of labor, supplies, materiels handling equipment (MHE), and facilities for the "hands on" depot receipt, storage and issue operations. Nominal costs were computed for two levels of modernization; current state-of-the-art and the future. Current state-of-the-art costs were based on off-the-shelf (FY 76) materiels handling technology and equipment in the private sector. "Future" costs were based on a ten year technological forecast which included advances in MHE technology and concepts, and predicted economic conditions of the FY

86 time frame. Nominal operating and investment costs reflect economies of scale associated with various throughput levels of materiel processed.

B. NOMINAL COST CONTENT

Nominal depot costs for model purposes are composed of engineered costs and historical costs. The engineered costs, hereinafter referred to as direct variable costs, represent the operational cost associated with modernized receipt, storage and issue functions and were developed using an industrial engineering approach. A portion of historical variable costs, hereinafter referred to as indirect variable costs, was then added to the direct variable costs to make the total nominal depot variable cost comparable with the baseline depot variable cost and suitable for optimization model analysis. Baseline depot fixed cost as computed in Appendix D-3, Section 2, was also used for model analysis. See paragraph D for a discussion of the derivation of indirect variable and fixed costs for use in nominal depot modeling scenarios.

C. DIRECT VARIABLE COST DEVELOPMENT

1. Components of Direct Variable Cost

Direct variable costs represent the basic difference between nominal and baseline depot costs and provide the decision maker an opportunity to compare existing depot materiels handling methods and system costs to a modernized system cost. The nominal direct variable costs are based on state-of-the-art and ten year (FY 86) forecasted warehousing and materiel processing systems using the most economic mix of labor, equipment and space. Optimum utilization of labor was assumed in the conceptual system by using DOD time standard data and warehousing techniques within the operating constraints prescribed by Service/DLA requirements. The direct variable cost is DODMDS product-related and reflects differences in economy of scale for levels of workload. Specific functional areas included in the direct variable cost are those described by DODI 7220.17 as receiving, packing, bulk issue, bin issue, shipping, and quality control. Preservation and packaging, care of materiel in

storage, rewarehousing, container manufacturing, and unit and set assembly are recognized as "hands on" materiel handling operations which could be improved with modernization. These functions were, however, omitted from the modernization portion of the nominal depot effort because they differ according to:

a. Service/DLA management policy;

b. Local depot maintenance requirements;

c. Local customer support policy;

d. Reparable-consumable commodity mix;

e. Depot prerogatives in contracting all or a portion of these functions.

Costs for these functions were included in the indirect variable cost portion of the total nominal cost.

2. Tasks in Nominal Development

Inherent in the objective of developing nominal depot direct variable costs were the following tasks:

a. Develop the data base;

b. Determine the materiel flow and physical characteristics which are the basis for the development of depot handling and storage systems;

c. Develop concepts of distribution center storage and handling systems which best utilize the state-of-the-art technologies;

d. Determine the state-of-the-art cost curves which represent these systems over various levels of throughput for each product group;

e. Prepare a ten year forecast of materiels handling and storage technology and costs;

f. Develop product related design concepts based on the technological forecast at different levels of throughput; and

g. Determine the cost curves for these technically improved design concepts.

To accomplish these tasks, the DODMDS study group contracted with Drake Sheahan/Stewart Dougall, Inc. (DS/SD), Marketing and Physical Distribution Consultants, to develop the nominal depot direct variable costs. A detailed explanation of the methodology used by DS/SD to produce state-of-the-art and forecasted (FY 86) nominal depot direct variable costs is contained in this appendix, Sections 5 and 6 respectively.

3. Data Base

The state-of-the-art direct variable cost data base described in Section 5 included:

a. Planning factors and assumptions;

b. FY 76 materiels handling equipment costs;

c. FY 76 construction or space costs;

d. FY 76 labor rates;

e. Materiels handling standard time data;

f. DODMDS receipt, asset and shipment (issue) workload data;

g. Internal depot flow data derived from the DODMDS Study Group Data Call;

h. DODMDS Materiel Flow Diagrams which were approved by the Services and DLA.

It should be noted that DODMDS asset and shipment data used in the nominal direct variable cost development, in Appendix D-3, Section 5, differs from systemwide wholesale asset and shipment data found in Chapter 3. Asset and shipment data provided to DS/SD by the study group were the best data available at the time but were overstated in comparison to the final DODMDS study group data. The impact of this overstatement was not significant enough to warrant recalculation of the direct variable costs.

Materiel flow and physical characteristics were determined by review and consolidation of DODMDS materiel flow diagrams and computation of receipt, storage and issue workload by unit of issue dimension and cube stratification. Wholesale receipts, assets and issues were categorized into large (any unit of issue having a dimension greater than four feet or unit of issue cube greater than 64 cubic feet) or small. Assets were also stratified by storage mode (cold, hazardous, security or general purpose). The development of DODMDS workload data by item characteristics and a sample materiel flow diagram can be seen in Exhibits F and G of Section 5, Appendix D-3.

4. Nominal Flow Paths

The nominal direct variable cost curve construction was based upon a flow path concept. A flow path is defined as the route taken by a group of commodities having similar handling and storage requirements from point of receipt in a depot to point of shipment. (See Table 3-1, page 3.6, for a list of the 11 flow paths). The supply depot functional work centers, i.e., receiving, inspection, storage, packing, shipping, and connecting transportation or interface links, are the elements which make up the flow path. The design of each flow path was based on the parameters, i.e., number of assets or storage locations, throughput level, physical characteristics of NSN's, and Service/DLA requirements for each element. Flow path construction consisted of three principal steps: (1) prepare alternatives for each element of a flow path and evaluate each alternative for operational and economic feasibility; (2) combine the elements into a total flow path system and evaluate results to determine total system effectiveness; and (3) describe the equipment/facility systems and operating methods to provide the basis for development of direct variable cost curves. See Appendix D-3, Section 5, Chapters 2 and 3, for a detailed explanation of the flow path concept, methodology, design and costing.

Table 3-1. Flow Path Description

Flow Path Number	Description
1	Items requiring cold storage
2	Hazardous items
3	Items requiring security storage
4	Small arms
5	Ships, boats, aircraft, railway equipment
6	Aircraft engines
7	Vehicles
8	Tires
9	Subsistence
10	All other items -- large (nonpalletizable items)
11	All other items -- small (bin and palletizable items)

5. Direct Variable Cost Development Steps

a. Once each flow path was costed out at discrete levels of throughput ($/CWT issued), cost curves or matrices were developed relating throughput (in CWT) to FY 76 cost of direct variable operational labor, supplies, and annualized investments in facilities and equipment. Direct variable costs are not depot specific, but do reflect differences in labor and construction costs by means of three depot groupings or regions as described in Exhibits C and D of Section 5, Appendix D-3. Resulting matrices are displayed in Exhibit E (Flow Path Cost Summaries), Section 5, of this appendix.

b. To make these costs compatible with DODMDS baseline costs, FY 76 direct variable costs were deflated to FY 75 by using a factor of 8 percent. This 8 percent factor was determined from an analysis of DOD deflator indices and the inflation indices provided in Section 6, of this appendix.

c. For optimization model use, nominal costs had to be expressed in cost per CWT by DODMDS product group rather than by flow path. To convert from dollars per flow path to dollars per CWT, flow path to product group factors (Reference Figure 3-1, Section 5) were utilized. The computation consisted of a summation across all 11 flow paths by DODMDS product group (by throughput level within depot grouping) of the FY 75 direct variable cost by flow path times the applicable flow path to product group conversion factor (percent of DODMDS product "A" in flow path "1"). Direct variable costs as the result of conversion were then added to historical (non-modernized) variable costs for modeling input data.

d. Direct variable costs reflecting only labor and supplies (annualized space and equipment investment excluded), were also developed for each flow path for specific throughput levels within each depot grouping. These costs were converted into direct variable cost rates ($/CWT) by product group in the same manner as total direct variable costs using the flow path to product group conversion factors.

e. Direct variable costs in both forms - total and labor/supplies only - provided the capability to: (1) compare nominal costs without capital investments to baseline costs which do not include capital investments; (2) determine the possible DODMDS annual cost and potential operational savings if nominal depot systems were implemented; and (3) determine if the capital investment is justified when included on an annualized basis.

6. Technological Forecast

Direct variable cost development based on the technological forecast (FY 86) followed the same pattern established for the state-of-the-art forecast, but was based on postulated equipment/facility capability derived from literature searches and interviews with industry suppliers, trade associations and users. Principal tasks of the forecast included: (a) identification of the technological changes expected by FY 36; (b) assessment of the impact of these changes on the direct variable cost areas; and (c) integration of the resulting cost changes into future (FY 86) direct variable cost curves. The forecast included a redefinition of the state-of-the-art as it is postulated in the FY 86 design year, together with a prediction of equipment costs and a forecast of the impact of future economic conditions on operating cost factors. The technological forecast, along with FY 86 direct variable costs by flow path, is provided in Section 6, of this appendix.

D. MODEL INPUT DATA

1. Indirect Variable Cost

The nominal depot direct variable costs correspond to only a portion of the historical variable costs. Thus, to be used as input data to the optimization model the direct variable costs must be combined with that portion of baseline variable costs which were classified as nominal depot indirect variable costs. Indirect variable functions include receipt document processing, freight, and all the depot storage and support functions (Reference Chapter 3, Appendix C,

Section 7). These functions include tasks which involve actual handling of materiel and use of materiels handling equipment. However, because of the requirements and operational differences between depots and the intent to develop a modernized system for materiel handling and storage functions applicable to any DODMDS depot structure, indirect variable functions were omitted from the DS/SD engineering effort. The assumption was made that indirect variable functions would not change in method or procedural operation and therefore, vary linearly with throughput. Indirect variable costs, by depot, were determined from baseline depot costs (Reference Appendix C, Section 8) and expressed as a cost per unit of throughput for each of the 69 DODMDS products and added to the direct variable rate for a total variable rate by product group by depot for model input. Using Depot K as an example, the nominal indirect variable cost for Depot K was based on Depot K's total baseline depot variable cost less the costs of those functions which were included in the direct variable costs. The procedure used in calculating Nominal Depot K's indirect variable costs was as follows:

a. Depot K's total baseline depot variable cost was determined by summing the costs identified under supply handling, supply storage and supply support from the DODMDS Historical Distribution Facility Costs (Chapter 3, Appendix C, Section 7). Baseline direct variable cost was determined by summing the costs from Depot K's functional accounts of receiving, packing, bulk issue, bin issue, shipping and quality control. The difference between these two values is equal to Depot K's total indirect variable cost. For example, assume Depot K's total baseline variable and direct variable costs equal $5.0M and $1.8M respectively. Baseline indirect variable cost is equal to $5.0M minus $1.8M or $3.2M. Therefore, 64 percent of Depot K's baseline variable cost can be classified as indirect variable cost.

b. Using the DODMDS derived baseline standard variable costs in $/CWT by product group, the indirect variable cost factor as calculated above was applied to determine indirect cost per CWT for each of the 69

product groups. For example, if the total standard variable cost for DODMDS Product 674 was \$5.00/CWT, the indirect variable cost for product 674 for Nominal Depot K is equal to \$5.00/CWT x 64 percent or \$3.20/CWT. This indirect variable cost for product group 674 was added to the nominal direct variable cost (\$/CWT) for the product 674 to arrive at the total Depot K nominal variable cost (\$/CWT) for product group 674 for optimization model input.

2. Nominal Depot Fixed Cost

Nominal depot fixed costs include those elements listed in Section 2B, Appendix D-3 as Supply Overhead. No attempt was made to adjust or change these costs because of modernization. These costs are not directly responsive to depot throughput but are required as input data in order to produce nominal depot costs comparable with the historical baseline and the outputs of modeling analysis.

E. THROUGHPUT ECONOMICS

Nominal depot variable costs per unit, unlike baseline predicted costs, vary with throughput levels. That is, the cost in \$/CWT to process 100,000 CWT's of product 674 is less than the cost in \$/CWT to process 50,000 CWT's. Nominal depots, by design are capable of processing the total DODMDS wholesale throughput or any part of it by product group. The range of throughput used for direct variable cost derivation was from the total DODMDS wholesale throughput down to 1/40 of the total wholesale throughput. Any volume lower than the 1/40 level was assumed to equal the 1/40 volume rate. The 1/40 volume level was selected as minimum level of depot throughput for design purposes.

F. SUMMARY

Nominal depot costs reflect a conceptual depot system encompassing state-of-the-art (FY76) and forecasted (FY 86) materiels handling and storage technologies and cost effective use of labor, equipment and facilities. Nominal depot costs provide the decision maker with a predicted "bound" in DODMDS total annual operating cost that could be realized through a maximum capital investment program.

SECTION 4
DEPOT CAPACITY

A. INTRODUCTION

This section deals with the development of data which are required to evaluate the physical capacity constraints at each depot in terms of throughput and storage in both the optimization and simulation models. It was necessary to represent depot capacity limits in order to evaluate the feasibility and performance aspects of structural alternatives. Additionally depot capacity is an important ingredient in a trade-off analysis between the number of materiel locations and the cost of depot expansion. These cost trade-offs cannot be developed without capacity benchmarks for each depot.

The physical capacity of a supply depot is the maximum capability of a depot to receive, store and issue materiel. In actual supply depot operations, maximum physical capacity is limited by the capability found at any one of a series of "choke" points in the functional processes. Under short term situations depot capacity can be expressed as a finite number of backlogs of receipts and issues. The following describes the development of data expressing depot capacity for input to the DODMDS study group models.

B. OPTIMIZATION MODEL DEPOT CAPACITY

1. Throughput

a. The purpose of using throughput capacity in the optimization process is to flag the instances where model assigned depot throughput is significantly greater than in the base year. Since the time

parameter of the optimization model is one year, depot throughput capacity must be expressed as a single number which represents the annual physical capability of a depot.

b. Depot capacity can be represented by any one of several parameters, i.e., a given depot can process x CWT, y line items, z cubic feet, etc., of materiel per year. When a particular commodity mix and volume reaches any or all of the maxima, that depot has reached its maximum capability. Using only a single parameter as the capacity variable, creates the possibility that the maximum capability, as reflected in one of the other variables, has been exceeded. The optimization model does not permit explicit simultaneous expression of capacity in multiple variables. Therefore, depot capacity was represented by a surrogate variable, weighted throughput, which reflects three parameters of depot workload. Weighted throughput is another term for standard depot variable cost, the procedures for deriving weighted throughput and standard depot variable cost are identical and are described in Section 2, paragraph B, of this appendix.

c. The annual depot capacity in the optimization analysis for each depot was assumed to be 25 percent greater than the historical wholesale weighted throughput. This assumption was in keeping with the recognition that depot fixed costs were valid over only a finite range of depot throughput in excess of history, i.e., a depot could increase throughput 25 percent above history with the same fixed cost structure. Table 4-1, page 4.3, displays the historical wholesale weighted throughput and the capacity value for each depot.

d. Two optimization model input parameters were required to reflect depot capacity in terms of weighted throughput:

(1) Maximum capacity (a single number) for each depot expressed in total weighted throughput.

(2) Difficulty Factor for each commodity. (The Difficulty Factors convert CWT per commodity of depot throughput to weighted throughput.)

Table 4-1. Depot Capacity For The Optimizer

	Depot	Historical Wholesale Weighted Throughput (In Millions)	Capacity[1] (In Millions)
1	ANAD	9.220	11.5
2	CCAD	3.902	4.9
3	LEAD	9.922	12.4
4	LBAD	3.706	4.6
5	NCAD	15.680	19.6
6	PUAD	3.613	4.5
7	RRAD	12.249	15.3
8	SAAD	9.532	11.9
9	SHAD	9.473	11.8
10	TOAD	6.320	7.9
11	TEAD	10.747	13.4
12	NASALA	3.365	4.2
13	NASJAX	2.354	2.9
14	NASNOR	4.881	6.1
15	NASNI	6.288	7.9
16	NSCNOR	9.512	11.9
17	NSCOAK	12.095	15.1
18	NSCPH	.522	.7
19	NSCSD	2.765	3.5
20	MCASCP	2.700	3.4
21	OCALC	19.093	23.9
22	OOALC	8.197	10.2
23	SMALC	7.468	9.3
24	SAALC	17.515	21.9
25	WRALC	12.244	15.3
26	MCLSBLANT	3.331	4.2
27	MCLSBPAC	6.894	8.6
28	DCSC	10.734	13.4
29	DDMP	22.290	27.9
30	DDMT	22.169	27.7
31	DDOU	17.820	22.3
32	DDTC	19.001	23.8
33	DESC	8.776	11.0
34	DGSC	16.252	20.3
TOTAL		330.618	413.3

[1]Capacity equals historical wholesale weighted throughput of each depot times 1.25.

e. The use of historical weighted throughput as a surrogate for annual depot capacity was considered appropriate since weighted throughput incorporated a variety of workload parameters and represented the proven capability of individual depots. Further, the use of weighted throughput and Difficulty Factors enabled the optimization model to accumulate the contribution of each commodity to the overall capacity of each depot whether or not that depot-commodity combination existed in the base year.

2. Storage

a. The optimization model uses CWT of throughput by product as the depot workload variable. Testing the availability of storage space associated with the throughput levels, determined by the optimization model, was required to prevent infeasible stockage patterns. As used in this section, the phrase "storage capacity," applies only to covered storage. In order to evaluate depot storage for various levels of throughput, it was necessary to convert CWT of throughput by product into cubic feet of storage. The data derived from this conversion process, when used in conjunction with data reflecting available storage space by depot, permits an evaluation of the storage requirement associated with a given level of throughput at each depot.

(1) Product Conversion Factors

(a) The DODMDS study group Cost Mini-File, described in Section 2, Part C of this appendix contains the wholesale shipments by commodity, CWT, depot and total system . The asset data file contains the wholesale assets, measured in cube on hand, at each depot and systemwide by product, at one time during the base year. The relationship between cubic feet of materiel on the ground and CWT of throughput was computed from these two data sources. This provided systemwide average cubic feet of assets per CWT of throughput, by product, during the base year (Table 4-2, page 4.5). The cube per CWT figures for Product Groups 152, 191, 221, 231, 232, 241 and 545 were adjusted downward by as much as 90 percent from the computed data. These product groups are primarily

Table 4-2. Product Conversion Factors

Product	Cube Per CWT	Product	Cube Per CWT
101	15.59	492	32.52
102	87.14	494	6.44
104	25.42	495	6.57
121	5.12	496	10.25
141	11.34	497	34.67
142	11.48	534	8.08
144	56.99	536	9.56
145	52.16	537	51.16
151	135.30	544	5.54
152	27.73	545	5.95
153	16.56	581	20.85
154	16.16	584	15.39
155	23.86	586	14.38
156	58.07	587	36.31
157	72.13	611	6.25
161	13.28	614	11.23
162	1.07	615	8.74
171	32.45	616	13.31
174	38.63	617	16.27
191	14.13	651	10.57
204	24.37	654	6.91
221	1.74	655	81.27
224	338.14	671	11.83
231	4.44	674	4.27
232	1.24	684	2.59
241	2.52	685	1.36
244	2.52*	714	24.66
264	12.83	715	26.35
265	4.10	844	15.04
281	4.49	845	47.00
294	7.48	894	1.10
295	7.53	895	1.00
296	10.49	994	20.68
297	22.05	995	12.06
491	13.50		

*After the completion of the analytical effort it was discovered that the correct product conversion factor for Product #244, Tractors, Construction Material, Small, is 69.15. The required storage space for this product would change from 19,960 cu. ft. to 547,737 cu. ft. The correct product conversion factor (69.15) will increase the system storage space requirement by .2 percent.

stored outside. The assumption was made that covered storage was not required for all NSN's in these groups and therefore only a percent of their total cube was considered in covered storage requirements. The cube per CWT for Product Group 492 was adjusted downward (by 63 percent) and for Product Group 895 was adjusted upward (the factor was set at 1.00) to compensate for NSN data anomalies within the product groups.

(b) The optimization model determines the CWT of throughput by product. The CWT of throughput by product was converted into cubic feet of asset storage by depot using the product conversion factors. Cubic feet of storage was not an active constraint in the optimization process, but was used in the analysis of each model run.

(2) Depot Storage Space.

(a) To determine the covered storage space available per depot, required the computation of baseyear storage capacity in cubic feet for each of the 34 depots.

(b) To arrive at baseyear depot storage space capacity, the DODMDS study group had two sources: the DD Form 805, Storage Space Management Report, 30 June 1976, which provided attainable cube of the depots; and secondly, Section F-25, Warehouse Configuration Data, DODMDS Data Call, which provided individual warehouse dimensions and net square feet of storage space.

(c) The DD 805 Storage Space Management Report, published semi-annually by OASD(Comptroller), provided storage data in cubic feet on 32 of the 34 depots. (The wholesale distribution storage space at Defense Depot Mechanicsburg and Corpus Christi AD is not reported separately from the respective host installation's storage space.) The DD 805 report contains inconsistencies in that some depots consider the space for receiving, shipping, P&P, etc. functions as storage space, while other depots distinguish between functional processing and storage space. In the latter case, functional areas are reported as

support space or are not reported at all. In addition, the DD 805 Attainable Cube (Line 11, Columns C and D) is determined by such factors as materiels handling equipment (MHE), security regulations, floor load capacity and density of materiel on an activity-by-activity basis. The DD 805 Attainable Cube does not appear to reflect the actual storage capability of a building or depot. For example, bins eight ft. high may be used in a building which measures 25 ft. from floor to ceiling. However, the depot reports only eight feet of the building as being attainable. If the need should arise, the depot could double the attainable cube by utilizing this unused available cube. In addition, total Net Cubic Feet (DD 805 Line 10, Columns C and D), as reported by some depots, is equal to the attainable cube on line 11, which makes the DD 805 suspect in comparability. Because of these deficiencies, the DD 805 report did not appear to be a desirable data source for measuring the covered storage capacity of the 34 depots.

(d) In lieu of the DD 805 data, storage capacity was derived from data reported in response to the DODMDS Data Call. Section F-25 of the DODMDS Data Call provided net square feet for storage of bulk, rack and bin materiel by building, as well as the ceiling heights of each building. From these data the net cube available for storage in each building could be computed by multiplying net square feet by ceiling height. However, because of trusses, fire sprinklers, structural losses and lift clearance, the reported ceiling height could not be used for materiel storage. The higher the warehouse ceiling, the greater the need for handling clearance by MHE. The following ceiling height restrictions were used: where reported ceiling height was 15 feet or over, three feet were subtracted from reported ceiling height; where reported ceiling height was 10 to 15 feet, two feet were substracted from reported ceiling height; and where reported ceiling height was under 10 feet, one foot was subtracted from reported ceiling height. Functional operations were excluded where reported separately. The above procedure was used for each of the 886 buildings, listed in Chapter 3 (Appendix C, Section 5)

used for storage in the base year. This provided a reasonable approximation of storage space available at each depot. Although some buildings may have more/less than three feet of unuseable space, the procedure is uniform for all depots.

(e) The deficiencies in the preceding approach, as opposed to the DD 805 are: (1) the method overstates actual storage capability for bulk storage, (2) actual stacking height restrictions in each building are unknown.

(f) Table 4-3, page 4.9, reflects the DODMDS study group derived storage space for each of the 34 depots. Table 4-3 reflects only materiel storage space. Where the separations could be made, space at each of the depots used for receiving, shipping, packing, preservation and packaging, container assembly, unit & set assembly, transshipment, administrative outgrants, other base operations, sheds, igloos, and fuel tanks were excluded from Table 4-3. The available storage cube is based on those warehouses in existence as of the spring of 1977 (DODMDS Data Call F-25 Update).

b. The baseyear storage capacity figures as shown in Table 4-3 were used to review the optimization model results to determine if the asset storage requirements, computed from the proposed depot workload in CWT, exceeded the physical depot storage limitations.

C. <u>SIMULATION MODEL CAPACITY</u>

1. <u>Requirement</u>

Daily depot throughput capacity is an essential data element for examining the performance time oriented aspects of depot workload for those DODMDS structures recommended by the optimization model. Appendix D-5, Section 3, provides a detailed description of the LREPS simulation model. Depot throughput capacity for the simulator is the maximum number of line items, or CWT which a depot can offer for shipment during an eight-hour day. It was assumed that additional labor could be employed, on a one-shift/five-day per week

Table 4-3. Depot Storage Space

Depot	Cube (Storage Only) (In Millions of Cu. Ft.)
ANAD	21.428
CCAD	4.314
LEAD	11.718
LBDA	19.808
NCAD	29.070
PUDA	24.162
RRAD	19.669
SAAD	13.819
SHAD	10.928
TOAD	26.174
TEAD	12.144
NASALA	13.753
NASJAX	7.815
NASNOR	8.456
NASNI	18.053
NSCNOR	41.706
NSCOAK	44.624
NSCPH	5.559
NSCSD	6.099
MCASCP	3.863
OCALC	19.943
OOALC	13.374
SMALC	19.644
SAALC	29.963
WRALC	18.616
MCLSBLANT	34.111
MCLSBPAC	26.196
DCSC	20.650
DDMP	71.736
DDMT	36.306
DDOU	48.669
DDTC	41.850
DESC	7.013
DGSC	54.001
DOD TOTAL	785.234

schedule, to accomplish any increased workload . The basic objective of using a simulation model to evaluate the system dynamics was to examine the physical capabilities of equipment and facilities rather than the budgetary aspects of labor shortfalls.

2. Development

Daily depot capacity was developed from data contained in the Wholesale Cost Mini-File (CMF). The CMF displays weight, cube, price and line items shipped during the DODMDS base year by depot. Additionally, the DODMDS Data Call requested each Service/DLA to provide: "Maximum production of receipt and issue line items per day (five day, 40 hour work week) with a margin of additional investment in facilities and/or equipment not to exceed $25,000." The responses to this data call were judged to be adequate for analytical purposes. It is recognized that in some cases throughput capacity was based on current commodity mix and volume and that capacity could change with a significant shift in commodity mix.

3. Capacity for the Simulation Model.

Depot capacity for simulation model purposes was computed by:

a. Determining the historical daily average workload per depot by dividing the base year wholesale workload discussed in Section II, Part C, by 251 working days (weekends and holidays excluded). Table 4-4, page 4.11, shows the historical daily average workload for each depot in terms of line items and CWT.

b. Determining a historical accelerated daily average workload per depot. The historical accelerated daily average represents a level of throughput which could have been achieved, daily, without any additional labor, equipment or facilities, if the actual workload exerted sufficient pressure on labor and management and thereby increased productivity. The data available did not provide a direct measure of the magnitude of productivity increases possible at each depot and, therefore, it was assumed that the historical daily average could be increased by 25 percent to represent these productivity increases.

Table 4-4. Daily Average Wholesale Workload[1] By Depot

	Depot	CWT	LIS
1.	ANAD	8,415	371
2.	CCAD	436	111
3.	LEAD	5,115	1,478
4.	LBDA	645	509
5.	NCAD	6,610	2,279
6.	PUDA	1,590	239
7.	RRAD	6,494	1,812
8.	SAAD	2,585	2,152
9.	SHAD	4,065	777
10.	TOAD	1,585	593
11.	TEAD	5,326	449
12.	NASALA	484	1,222
13.	NASJAX	363	895
14.	NASNOR	613	1,099
15.	NASNI	1,247	1,446
16.	NSCNOR	4,851	6,218
17.	NSCOAK	5,674	5,449
18.	NSCPH	546	345
19.	NSCSD	1,994	848
20.	MCASCP	400	738
21.	OCALC	2,728	3,754
22.	OOALC	1,380	2,346
23.	SMALC	1,433	1,847
24.	SAALC	3,021	3,458
25.	WRALC	1,826	2,873
26.	MCLSBLANT	1,609	450
27.	MCLSBPAC	3,260	804
28.	DCSC	2,525	8,619
29.	DDMP	20,413	1,467
30.	DDMT	12,663	12,424
31.	DDOU	3,605	15,017
32.	DDTC	13,489	5,268
33.	DESC	315	9,784
34.	DGSC	7,049	4,520
	TOTAL	134,354	107,802

[1] DODMDS study group base year wholesale workload divided by 251.

c. The daily capacity level per depot was determined on the basis of information provided by the Services/DLA from the updated F-37 section of the DODMDS Data Call. The daily issue capacity data reported in the F-37 data was divided by the historical accelerated daily average workload in terms of line items. The resulting ratio was used to postulate depot daily capacity in terms of CWT by multiplying the accelerated daily average workload computed in paragraph b by this ratio. In those cases where depots did not furnish updated F-37 capacity data, the daily capacity was assumed to be 1.5 times greater than accelerated historical daily average workload, or 1.75 above the base year. In cases where the F-37 depot capacity data were lower, the accelerated historical daily average workload was used. Table 4-5, page 4.13, reflects the daily capacity data used for the simulation model.

4. Mobilization Capacity

Depot capacity, Table 4-5, was established as described in the above paragraphs. Mobilization capacity was established as three times the eight-hour shift. This simple method assumes all shifts to be equally productive. The simple straight line projection eliminates the need for arbitrarily reducing second and third shift output by some factor.

5. Summary

The daily depot capacity data computed by the above methods permitted performance time analysis of system structures (depot-commodity mix and volumes suggested by the optimization process). Annual depot capacity is sufficient for defining basic system structural alternatives, but performance time analysis in terms of line items or CWT, on a daily basis, is necessary for dynamic evaluation of the system structure.

Table 4-5. Daily Depot Capacity For The Simulator

		CWT	LIS
1.	ANAD	17,200	800
2.	CCAD	4,250	1,700
3.	LEAD	7,000	2,000
4.	LBDA	1,100	800
5.	NCAD	23,200	8,000
6.	PUDA	4,000	600
7.	RRAD	15,400	4,300
8.	SAAD	3,200	2,700
9.	SHAD	18,900	3,700
10.	TOAD	2,200	800
11.	TEAD	43,500	3,800
12.	NASALA	1,000	2,500[1]
13.	NASJAX	800	1,700[1]
14.	NASNOR	1,500	2,700[1]
15.	NASNI	2,900	3,200[1]
16.	NSCNOR	13,400	17,300
17.	NSCOAK	14,400	13,400
18.	NSCPH	1,400	800
19.	NSCSD	3,300	1,400
20.	MCASCP	1,400	3,300[1]
21.	OCALC	10,900	14,900
22.	OOALC	7,300	13,100
23.	SMALC	11,000	14,000
24.	SAALC	12,200	13,700
25.	WRALC	9,400	14,800
26.	MCLSBLANT	20,200	6,100
27.	MCLSBPAC	20,900	5,100
28.	DCSC	3,200	10,800[2]
29.	DDMP	25,500	9,300[2]
30.	DDMT	15,800	15,500[2]
31.	DDOU	4,500	18,800
32.	DDTC	18,600	7,100
33.	DESC	400	12,200[2]
34.	DGSC	8,800	5,700[2]
	TOTAL	348,750	236,600

[1]Updated F-37 data not submitted.
[2]Updated F-37 data less than DODMDS study group base year wholesale workload times 125 percent.

SECTION 5
DEVELOPMENT OF NOMINAL
DEPOT OPERATING COSTS

HIGHLIGHTS

Direct variable nominal depot operating costs were developed to provide input to the DODMDS Study Group computer models, and to provide a basis of comparison with which to identify areas of improvement potential. These nominal costs include annual costs for labor and supplies, and annualized costs for new space and equipment. They reflect the current state-of-the-art in materials handling technology and management practices and were constructed without constraints imposed by facilities or systems at existing locations.

COST DEVELOPMENT APPROACH

Nominal depot costs were developed on the basis of materials handling flow paths. Eleven flow paths, each consisting of NSN's having similar handling and storage requirements, were identified and structured from the Study Group data base:

Materials Handling Flow Paths

Number	Description
1	Items requiring cold storage
2	Hazardous items
3	Items requiring security storage
4	Small arms
5	Ships, boats, aircraft, railway equipment
6	Aircraft engines
7	Vehicles
8	Tires
9	Subsistence
10	All other items -- large (nonpalletizable items)
11	All other items -- small (bin and palletizable items)

Each flow path was described in terms of its elements or work centers -- receiving, storage, replenishment, order selection (issuing), packing, and shipping.

The parameters of each flow path -- active and inactive assets, inbound and outbound throughput, item physical characteristics, and DODMDS requirements -- were quantified and formatted to define the workload for each flow path element.

Alternative handling and storage concepts were defined and evaluated to develop the most economical method of satisfying workload requirements for various levels of throughput volume.

FINDINGS

1. Unit costs per hundredweight developed for each flow path at the maximum and minimum throughput levels are:

Flow path number	Unit cost at maximum throughput level (dollars per hundredweight)	Unit cost at minimum throughput level (dollars per hundredweight)
1	89.50	180.00
2	0.78	1.91
3	4.91	24.19
4	9.69	12.44
5	1.81	5.46
6	3.54	7.88
7	2.12	5.37
8	3.36	6.03
9	0.62	0.91
10	12.10	30.86
11	7.07	8.51

Lower unit costs at maximum throughput than at minimum throughput indicate economies of scale are introduced as throughput increases for each flow path.

2. Flow Paths Nos. 7, 9, 10, and 11 -- Vehicles, Subsistence, All Other Items (Large), and All Other Items (Small) -- represent 95 percent of total DOD system nominal costs. At the maximum throughput level, the total cost mix by flow path is:

Flow path number	Description	Total annual cost (millions of dollars)	Percent of total
7	Vehicles	13	6
9	Subsistence	7	3
10	Large items	81	39
11	Small items	97	47
1-6, 8	All other products	10	5
	Total system	208	100

3. The DOD wholesale distribution system has a relatively low annual inventory turnover rate of 0.7 turns per year and is primarily a storage system. This storage orientation is reflected by the dominance of space cost in the total system nominal cost. At the maximum throughput level, the significance of each major cost element is:

	Total annual cost (millions of dollars)	Percent of total
Space	87	41
Equipment	43	21
Labor	72	35
Supplies	6	3
Total	208	100

4. Automation and sophisticated mechanization are not economically justified for most handling functions. Costs are sensitive to space savings because of the relative insignificance of throughput. Space utilization improvements tend to dominate economic analyses at the expense of mechanization dependent upon labor savings for justification. Mechanization for process functions such as receiving, inchecking, and packing, in which throughput volumes are large and unrelated to storage, are justified and used in the nominal cost development.

EXECUTIVE SUMMARY

A. INTRODUCTION

A key task included in the scope of work under the Drake Sheahan/Stewart Dougall Inc. contractual support effort for the DODMDS Study Group was the development of nominal depot storage and handling costs.

The objective of this effort was to develop a set of engineered depot costs, including annual costs for labor and supplies, and annualized space and equipment costs, that would be incurred if an entirely new wholesale distribution system were constructed without constraints imposed by facilities or systems at existing locations. The costs developed reflect the current state-of-the-art in technology and materials handling management practices and provide anticipated operating costs at various levels of throughput volume and various mixes of product groups.

Only direct variable storage and handling costs are included -- those for receiving, nontechnical inspection, storage, issuing, packing, shipping, and internal transport. Indirect variable and other fixed costs associated with depot supply operations are to be developed by the Study Group and combined with the direct variable nominal costs for distribution modelling inputs.

Within the overall DODMDS Study Group framework, nominal depot operating costs provide:

1. A frame of reference with which to identify the boundaries of the depot cost segment of the wholesale distribution system. In this role, distribution system configurations developed in the modelling process using nominal depot cost inputs represent an ideal or objective system. All facilities and equipment systems are new and all operating concepts and methods are economically justified.

2. A basis of comparison to identify modernization potential within functional areas at existing locations. Historical and nominal costs are to be compared by the Study Group to identify and quantify potential operational improvements.

3. A set of standardized operational costs, free of existing conditions and inefficiencies, which treat each location on an equal basis to identify and analyze distribution system sensitivities to other major cost functions such as transportation and depot-fixed costs.

The approach, methodology, and results of the nominal cost development effort are documented in the attached Report and summarized in the following pages.

B. APPROACH

Nominal depot costs were developed around the materials handling flow path concept. A materials handling flow path is defined as a group of NSN's having similar handling and storage requirements.

1. Flow Paths

DODMDS items were structured into eleven flow paths:

Flow path number	Description
1	Items requiring cold storage
2	Hazardous items
3	Items requiring security storage
4	Small arms
5	Ships, boats, aircraft, railway equipment
6	Aircraft engines
7	Vehicles
8	Tires
9	Subsistence
10	All other items -- large (nonpalletizable items)
11	All other items -- small (bin and palletizable items)

These specific flow paths were selected because they:

a. Represent reasonable homogenous groups of items thus facilitating development of accurate nominal costs.

b. Isolate items having special handling and storage requirements that may significantly affect cost.

c. Segregate major materiel groups (vehicles, subsistence, large items, small items) into large individual flow paths allowing identification of economy of scale potential.

d. Have the direct relationship to DODMDS product groups required for modelling analysis.

2. Flow Path Elements

Functional work centers were defined for each flow path. These work centers -- receiving, storage, replenishment, order selection, packing, and shipping -- were described in terms of their daily workload requirements and the flow of materiel over the transport links connecting them. Nominal concepts and costs were developed to satisfy the workload requirements of each element of each flow path.

3. Flow Path Parameters

Each flow path was defined in terms of four major parameters: assets, throughput, physical characteristics of NSN's, and DODMDS depot requirements. Information was extracted from the Study Group data base to identify and quantify each of these parameters.

In total, nominal concepts and costs developed satisfy the total wholesale distribution system requirements. These total requirements are shown in Figure 1. In terms of cubic feet, the most consistent measurement of handling and storage requirements, the DOD wholesale distribution system, consists of 334 million cubic feet

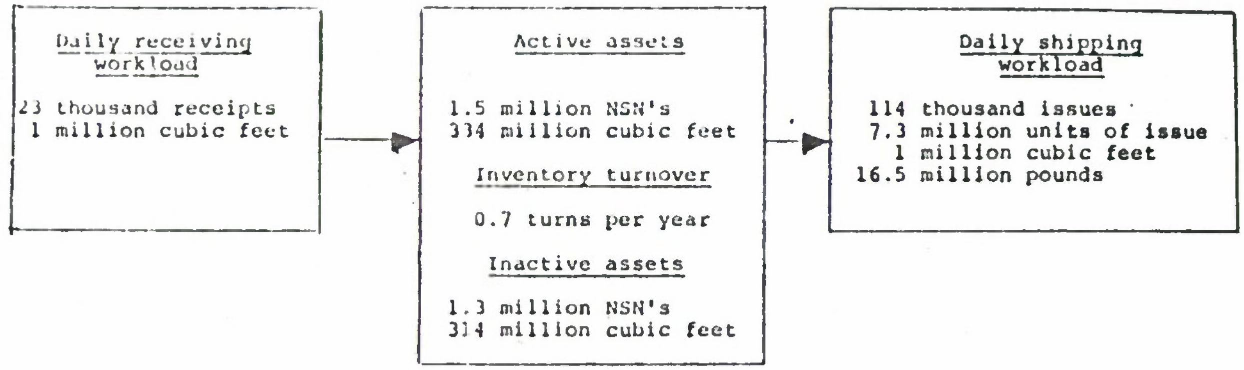

Figure 1

Total System Requirements

of active inventory supporting 1 million cubic feet of daily shipments. Overall annual inventory turnover is 0.7 turns per year. Shipments from inventory are replenished by an equal amount of receipts on an average daily basis. In addition to the active assets, 314 million cubic feet of inactive materiel are stored in DOD facilities. These assets represent materiel which had no issues during the Study base year.

4. Analysis Technique

Nominal costs were developed in four major steps: data base development, definition of costs to be developed, preparation of conceptual designs, and conversion of cost data to model input format.

a. Data Base Development. The first step involved collecting and formatting essential information and data elements including:

- Planning factors and assumptions.
- Materials handling equipment costs.
- Space costs.
- Labor rates.
- Materials handling standard time data.
- Throughput and asset data by flow path.
- Internal depot flow data.

These data were obtained and/or derived from sources within the Study Group to the maximum extent possible. Information from outside sources, such as equipment and space cost estimates, was assembled to supplement data made available by the Study Group. Three sets of space costs and labor rates were developed to reflect geographical differences and to allow nominal costs to be calculated for geographical groupings of depots.

b. Definition of Costs to be Developed. In this step, descriptions of each operation to be costed were written and the basic methodology determined. The cost development effort was divided into three analysis segments: storage system analysis, outbound flow analysis, and inbound flow analysis.

c. Preparation of Conceptual Designs. All depot operations were divided into two categories -- those requiring the evaluation of alternatives (variable cost functions), and those not requiring alternative evaluation (constant cost functions). At this point, the relative significance of flow paths and of individual work centers was considered to give emphasis to those of most importance.

This initial evaluation highlighted the significance of four specific flow paths in the total system environment -- Vehicles, Subsistence, Large Items, and Small Items, Flow Paths Nos. 7, 9, 10, and 11.

As illustrated in Figure 2, these four flow paths represent at least 86 percent of all system requirements, and a greater percentage of most requirements.

These four flow paths were selected for special emphasis in the cost development process. Costs for the remaining flow paths were developed statistically, using these four as a base with consideration given to special requirements by adjusting appropriate cost factors.

Another important insight from this initial evaluation was that the annual turnover of all flow paths, except those for Aircraft Engines and Subsistence, was low, indicating the dominance of storage costs in the overall system. Annual turnover rates for each flow path are listed in Figure 3.

This finding indicated that storage-related functions should be emphasized and reduced the importance of other, more throughput-related functions. As a result, flow path elements designated as constant cost functions were: unloading, checking, inspection, packing, and loading. Alternative method evaluation for these functions

Flow paths		Percent of daily receipts		Percent of assets				Percent of daily shipments		
				Active		Inactive				
Number	Description	Receipts	Cube	NSN's	Cube	NSN's	Cube	Issues	Cube	Weight
7	Vehicles	-[a]	17	-[a]	25	-[a]	2	-[a]	14	15
9	Subsistence	3	11	-[a]	2	-[a]	-[a]	31	14	27
10	Large items	5	35	2	26	2	67	1	24	16
11	Small items	90	27	97	40	98	30	67	34	33
1-6, 8	All other products	2	10	1	7	-[a]	1	1	14	9
	Total	100	100	100	100	100	100	100	100	100

[a]Less than 0.5 percent.

Figure 2

Significance of Flow Paths -- System Requirements

Flow paths: Number	Flow paths: Description	Annual average turnover rate of active assets (turns per year)
1	Cold	1.8
2	Hazardous	1.9
3	Security	1.1
4	Small arms	0.4
5	Ships/boats, etc.	1.1
6	Aircraft engines	5.0
7	Vehicles	0.4
8	Tires	1.5
9	Subsistence	5.6
10	All other -- large items	0.7
11	All other -- small items	0.6
	Total system average	0.7

Figure 3

Annual Turnover

was not needed. A single method for each function was selected and costed. Costs were reduced to a unit basis to facilitate applications at all levels of throughput.

Variable cost functions requiring analysis of alternative operating methods were determined to be storage, internal transport, issuing, accumulation, and sortation. Investment requirements and annual operating costs for each alternative method were developed and evaluated on an incremental basis. Economically justified concepts for various throughput ranges were established and costed.

d. Conversion of Cost Data to Model Input Format. Constant and variable annual costs for each flow path at each throughput level were combined. The throughput range for each flow path is bounded by a maximum value (total DODMDS wholesale volume for that flow path) and a minimum value (1/40 of total system volume -- assumes that any flow path would be found in no more than 40 locations).

C. FLOW PATH COST CHARACTERISTICS AND FINDINGS

1. Cost Characteristics

Nominal unit costs resulting from the development effort are listed in Figure 4. Unit costs are shown for each flow path in terms of weight and cube, for the maximum and minimum levels of throughput activity. Costs per hundredweight are needed for modelling use. Costs per cubic foot are shown as they are more meaningful as a measure of handling and storage difficulty. Materiel density differences among flow paths are also reflected in the cube-related costs.

Of the four significant flow paths, Subsistence has the lowest unit cost. Flow Path No. 10, Large Items, has the highest. These costs reflect the relative difficulty of handling and storing large, bulky, irregular items versus handling and storing the more uniform items of subsistence.

Flow paths		Unit costs[a]			
		At maximum throughput level		At minimum throughput level	
Number	Description	$/cwt.	$/cubic foot	$/cwt.	$/cubic foot
1	Cold	89.50	13.43	180.00	27.00
2	Hazardous	0.78	0.30	1.91	0.73
3	Security	4.91	0.36	24.19	1.83
4	Small arms	9.69	2.00	12.44	2.55
5	Ships/boats, etc.	1.81	0.10	5.46	0.30
6	Aircraft engines	3.54	0.52	7.88	1.17
7	Vehicles	2.12	0.37	5.37	0.93
8	Tires	3.36	0.29	6.03	0.52
9	Subsistence	0.62	0.21	0.91	0.30
10	Large items	12.10	1.38	30.86	3.52
11	Small items	7.09	1.13	8.51	1.36
	Total system average	5.01	0.83	9.42	1.57

[a]Cost values for Depot Grouping (Region) II.

Figure 4

Unit Nominal Handling and Storage Costs

The significance of the four flow paths given emphasis in the cost development process is highlighted by the listing shown in Figure 5.

Approximately 95 percent of the total system nominal cost is represented by Vehicles, Subsistence, Large Items, and Small Items.

The lower unit cost at maximum throughput than at minimum throughput for all flow paths, as shown in Figure 4, indicates the introduction of economies of scale as throughput increases. These economies of scale are shown in a different format in Figure 6 for the four main flow paths.

Flow Paths Nos. 7 and 10, containing large, bulky items, exhibit more economy of scale potential than do those for Subsistence and Small Items. Economies of scale for Flow Paths Nos. 7 and 10 are due to better utilization of labor, equipment, and space, rather than to mechanization. Significant investments for specialized equipment such as cranes, and fixed crew sizes to man this equipment, are needed at the lowest throughput levels. As throughput increases, better utilization results.

The absence of large initial investments at low volume levels for Subsistence and Small Items, and the small potential for mechanization due to the storage orientation of requirements, contribute to the small economy of scale potential for these flow paths.

The dominance of space in the overall system requirements and cost is evidenced in Figure 7. At both maximum and minimum activity levels, space represents the greatest single cost element -- approximately 42. percent of the total in both cases.

A second insight illustrated in Figure 7 concerns the reversal in cost mix between labor and equipment at the two throughput range end points.

As throughput increases, total equipment cost decreases and labor increases. These trends indicate that

Flow paths Number	Description	At maximum throughput level: Total annual cost[a] (millions of dollars)	Percent of total	At minimum throughput level: Total annual cost[a] (millions of dollars)	Percent of total
7	Vehicles	13	6	0.8	8
9	Subsistence	7	4	0.3	3
10	Large items	81	39	5.2	53
11	Small items	97	46	2.9	30
1-6,8	All other products	10	5	0.6	6
	Total system	208	100	9.8	100

[a]Depot Grouping (Region) II values.

Figure 5

Significance of Flow Paths -- System Costs

Flow paths		Economy of scale ratio[a]
Number	Description	
7	Vehicles	2.53
9	Subsistence	1.47
10	Large items	2.55
11	Small items	1.20

[a]Ratio of unit cost at minimum throughput level to unit cost at maximum throughput level.

Figure 6

Economies of Scale

Cost element	At maximum throughput level: Total annual cost[a] (millions of dollars)	At maximum throughput level: Percent of total	At minimum throughput level: Total annual cost[a] (millions of dollars)	At minimum throughput level: Percent of total
Space	87	41	4.2	43
Equipment	43	21	3.3	33
Labor	72	35	2.1	22
Supplies	6	3	0.2	2
Total	208	100	9.8	100

[a]Depot Grouping (Region) II values.

Figure 7

Handling and Storage System Cost Elements

more and/or more sophisticated mechanization does not become economically justified with throughput increases. This is due partly to the low system turnover rates and partly to the one-shift-per-day operation criterion used. This criterion reduces mechanization utilization, thus reducing the potential for economic justification.

2. Findings

Findings or conclusions reached from the nominal cost development can be divided into two categories: system attributes and cost sensitivities.

a. System Attributes. The DODMDS is primarily a storage system. The total system annual turnover rate of 0.7 is low in comparison to that of commercial distribution systems and systems in the non-DOD government sector. This low turnover rate reduces the significance of handling requirements and costs and directs emphasis to storage and storage-related functions.

DOD wholesale distribution system activity consists mainly of three types of commodities -- vehicles, subsistence, and small parts. The flow paths containing these items represent 75 percent of the total weight shipped.

Inventory in the DOD system is dominated by three flow paths -- those containing vehicles, small parts, and large items. The remaining eight flow paths represent only nine percent of total system active assets.

It should be noted that the turnover rate of 0.7 considers only active assets. If inactive assets are included in the turnover calculation, the annual rate is reduced by almost 50 percent.

b. Cost Sensitivities. Nominal costs reflect the storage orientation of the DODMDS. Not only is space cost the largest single cost element at all levels of throughput, but space savings are the dominant factors in evaluation and selection of alternative concepts. Use of storage aids and techniques to improve space utilization plays a more important role in economic analyses than does mechanization that is dependent upon labor savings.

In addition to the significance of space, other factors impact the difficulty in economically justifying handling mechanization. The physical nature of items in some flow paths, such as vehicles and other large bulky items, does not present attractive opportunities for mechanized handling.

Order characteristics in some flow paths, such as subsistence, also do not lend themselves to mechanization. For example, the case picking operation of subsistence, which would appear to have the requirements necessary to justify automated case picking machines, has characteristics which reduce this potential. Instead of many items of few cases each, subsistence orders consist of few items with many cases of each. This characteristic tends to minimize the principal advantages of case picking machines, namely reduction of travel time to several stock locations and simultaneous picking from several locations.

In the process functions such as receiving, inchecking, and packing, where throughput volumes are large and unrelated to storage, machines and mechanization such as conveyor and sortation systems are justified and employed in the cost development.

CHAPTER 1
INTRODUCTION

A. BACKGROUND

One of the primary objectives of the Department of Defense Materiel Distribution System Study is to develop and evaluate wholesale distribution system configuration alternatives. Each configuration alternative includes the number of depots; depot locations; and the mission of each depot in terms of product groups stored and handled, and the level of throughput activity by product group. The service levels and annual operating costs resulting from each alternative configuration are calculated. Annual operating costs are developed for materials handling and storage activities at each depot, for each transportation link external to the depots, and in total. Required investment costs, to the extent necessary for evaluation of a configuration alternative, are developed.

The study effort includes the development and evaluation of distribution system configuration alternatives under three basic scenarios regarding depot operating costs, as well as under combinations of these scenarios. The scenarios are:

1. Historical Depot Costs

In this scenario, configuration alternatives using handling and storage costs for commodities based on historical depot operating costs are evaluated. Alternative configurations result essentially from relocating product groups to depot locations having the lowest operating cost for those product groups, in combination with the optimum transportation network.

2. Nominal Depot Costs

Nominal depot operating costs are defined as those annual operating costs, including annualized investment costs for new space and equipment, that would be incurred if an entirely new wholesale distribution system

were constructed with no constraints imposed by existing facilities or systems. These nominal costs are engineered costs and assume effective labor scheduling and control. In essence, configurations based on nominal depot operating costs disregard completely facilities and equipment at existing locations. Equipment, facilities, and methods utilized in developing nominal depot costs reflect the current state-of-the-art in technology and management practices.

3. Future Depot Costs

This scenario includes configuration alternatives in which depot operating costs are based on nominal costs and concepts projected ten years into the future (Fiscal Years 1976-1986). Consideration of future wholesale distribution system configurations, as part of the DODMDS Study, should assist in avoiding short-term decisions that might preclude long-term goals.

* * * * * * *

Development of the costs to support the third scenario listed above, Nominal Depot Costs, is the subject of this Report. Five elements are present in the cost development process:

- Requirements.
- A methodology.
- A cost development process.
- Model input data.
- Findings.

This Report contains a description of the system requirements and how they were developed, a discussion of the methodology and approach used to generate costs, a listing of the resulting data to be used for model input, and the salient findings extracted from the cost development process.

The cost development process itself is not detailed in this Report. Documentation of this process, including all notes, calculations, assumptions, evaluations, and data formats, was submitted to the Study Group separately in several bound volumes of workpapers. Hard copies of all computer-generated data formats were also submitted separately to the Study Group.

Figure 1-1 shows the five cost development elements and their interrelationship in diagrammatic form.

B. OBJECTIVE

The objective of the effort summarized in this Report was to develop a set of nominal depot cost curves in a format suitable for use in the modelling process.

These cost curves:

- Represent economically justified handling and storage systems and concepts that satisfy operational requirements at various levels of volume throughput.

- Represent the sum of annual costs for labor, equipment, space, and supplies. Investment costs for equipment and space are annualized according to predetermined depreciation periods.

- Include only the direct variable segment of depot operating cost. Functions included are receiving, nontechnical inspection, storage, issuing, packing, shipping, and internal transport. Indirect

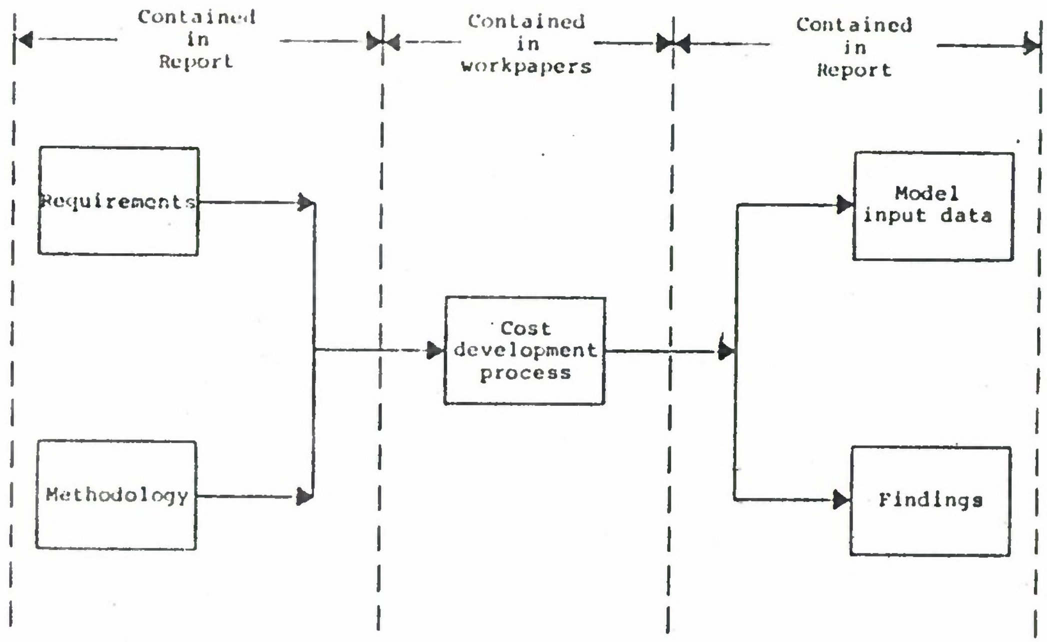

Figure 1-1

Nominal Cost Development Elements

variable and other fixed costs
associated with depot supply
operations are to be developed
by the Study Group and combined
with direct variable costs for
modelling use.

CHAPTER 2
APPROACH AND METHODOLOGY

The central concept in our approach to the development of nominal depot costs is the materials handling flow path. A materials handling flow path is defined as a group of NSN's which have similar handling and storage requirements. Determination of these flow paths, their parameters, and the NSN's included in each is fundamental in developing consistent and accurate cost estimates. Not only are materials handling and storage systems limited as to the range of materiel types they can feasibly serve, but alternative costing techniques, such as using weighted average costs for handling a wide variety of items, may result in cost estimates that are so general as to be meaningless for even gross analytical purposes.

Another concept deserving emphasis is the relationship between materials handling flow paths and DODMDS Study Group product groups. A product group is a grouping of NSN's as defined by the Study Group commodity aggregation strategy. Makeup of product groups is important to the optimization modelling process as well as to the determination of flow paths for nominal cost development. A product group may exist in one or more flow paths.

The optimization model considers a product group to be a single commodity and cannot treat NSN's below the product group level. Product groups may be located in several depots but always with the same NSN mix. In addition, the model requires one cost curve for each product group.

The DODMDS Study Group data base, upon which nominal depot workload requirements and costs are based, is structured in terms of product groups.

Since the optimization model considers costs in terms of product groups, and nominal depot costs are developed in terms of materials handling flow paths, a relationship between these two item groupings must be defined.

Definition of specific flow paths and their relationship to product groups is discussed in detail in Chapter 3.

A. FLOW PATH ELEMENTS AND PARAMETERS

Flow path elements re the functional areas or work centers within a dep : that must be considered in developing handling and storage costs. The major flow path elements considered (receiving, storage, replenishment, order selection, packing, shipping, and internal transport) are shown in Figure 2-1[a]. This diagram illustrates major flow path elements as functional work centers with connecting transport links. Workload volumes in each work center and flow volumes over each transport link were developed from the Study Group data base. These volumes are expressed in terms of NSN's, pallets, cases, cubic feet or weight, depending upon available data and significance of measurement units in determining costs.

Four major parameters of each flow path were considered in developing nominal costs: assets, throughput, physical characteristics, and DODMDS depot requirements.

1. Assets

Assets are the dominant factor in facility size determination. The storage requirements are a function of the asset lot sizes and the number of locations (aisle faces) needed.

Asset data were extracted from the Study Group automated data base. These data were then separated into two distinct groups: active assets or those NSN's that were issued during the base year, and inactive assets or those NSN's that had no issues during the base year. Storage requirements may be different for each of these

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[a]A more detailed flowchart of internal depot functions is shown in Exhibit G, Schedule G-II.

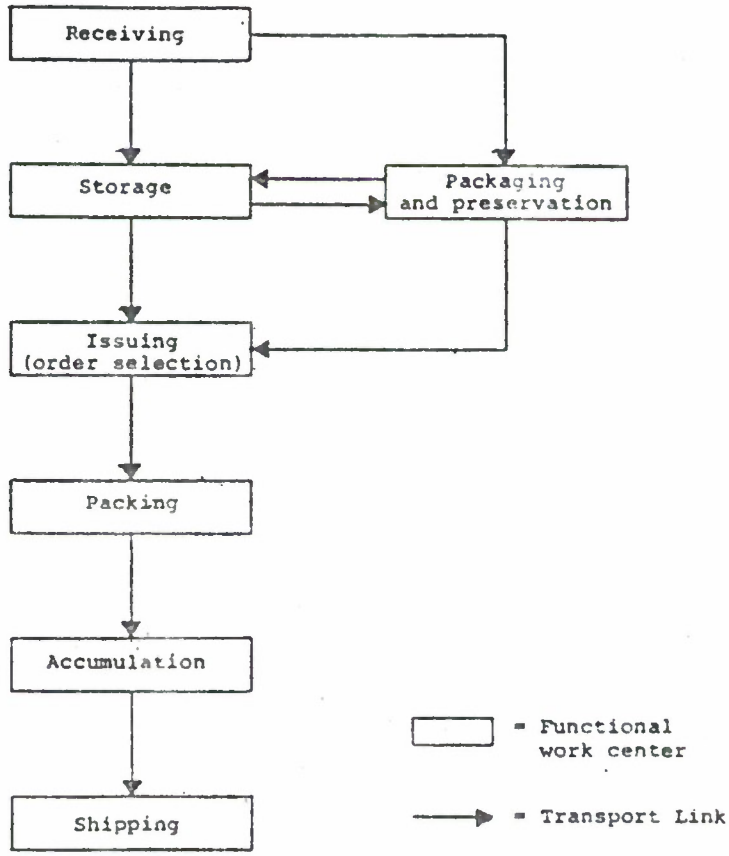

Figure 2-1

Flow Path Elements

two groups within a flow path. Thus, their identification and separation allowed individual cost development for each.

Assets are not only important alone, but also in their relationship to throughput. The annual turnover for each flow path was a key factor in evaluating forward and reserve picking concepts and establishing replenishment workload.

The units of measure of assets were lot sizes (or quantity per NSN) in terms of units of issue, cubic feet, pallets, and cases.

2. <u>Throughput</u>

Throughput is the prime determinant in the nature of the handling and storage systems selected. Nominal cost curves reflect some economies of scale through mechanization based on levels of throughput volume.

Throughput data were extracted from the Study Group procurement and demand data files. These data were processed to generate, for each flow path, a range of throughput from the maximum to the minimum expected. Maximum throughput was the entire DOD wholesale system volume for that flow path, that is, considering that the entire system throughput for that flow path was to be housed in a single location. The minimum throughput level for each flow path was determined to be 1/40th of the maximum, that is, considering that a flow path throughput would be no smaller than 1/40th of the total wholesale volume.

Cost/volume regions over the entire throughput range were established for each flow path. The boundaries of these regions were those volume levels at which a change in the nature of economically justified handling and storage systems occurred.

Throughput was measured in terms of receipts, issues, units, pallets, cases, NSN's, units of issue, cubic feet, and hundredweight.

Conversion of units of measurement to hundredweight was required to develop costs consistent with optimization model needs.

3. Physical Characteristics

The third flow path parameter considered was the physical characteristics of NSN's. In combination with assets and throughput, NSN physical characteristics define the flow paths.

Such NSN characteristics as dimensions, cube, weight, and special storage conditions (cold, hazardous, security) were considered.

4. DODMDS Depot Requirements

DODMDS requirements, in terms of issue priority groups, were considered in developing nominal depot costs. Although the nominal concepts and systems were designed to process the average daily requirement on a one-shift-per-day basis, priority group distributions were developed and used to determine picking workloads and shipping requirements.

B. ANALYSIS TECHNIQUE

Four major steps were involved in developing the nominal handling and storage cost for each flow path:

- Develop the data base.
- Define the costs to be developed.
- Prepare conceptual designs.
- Develop input data for models.

1. Develop the Data Base

The first step in cost development was to collect and assemble data in usable formats. Important elements are listed below and described in detail in the Exhibits accompanying this Report.

a. Planning factors and assumptions. Criteria upon which the cost development was based were established through investigation and discussions with Study Group members. These criteria are listed in detail in Exhibit A.

b. Materials handling equipment costs. Current cost estimates for equipment items and systems were obtained (largely through interviews with manufacturers), and structured into a usable format. These estimates are documented in Exhibit B.

c. Construction costs. Costs of new construction for various types of space (general purpose, cold, hazardous, security, rack supported) were obtained from various sources, including building contractors, architects, and the Air Force Institute of Technology. Geographic differentials were developed and applied to these basic cost estimates to reflect conditions at existing depot locations. Exhibit C contains all space costs, their sources, and development calculations.

d. Labor rates. Labor costs were developed from historical costs at existing depot locations. Geographic differentials were developed and adjustment factors applied to obtain hourly and annual productive labor rates. These rates and their development are shown in Exhibit D.

e. Materials handling standard time data. Standard times were obtained or derived from DOD Time Standards Manual for materials handling and warehousing (see Schedule A-I for reference number).

f. Throughput and asset data by flow path. Overall workload and storage requirements were developed from the DODMDS Study Group data base. This development is described in Exhibit F.

g. Internal depot flow data. Workload requirements specific to individual flow path elements were derived from the DODMDS Facility Data Call and existing Study Group data reports. The development of internal flow data, including an operational flowchart showing individual work centers, is documented in Exhibit G.

2. Define the Costs to be Developed

In this step, descriptions of each operation to be costed were written and the basic methodology for developing nominal costs determined. The cost development effort was divided into three main segments:

a. Storage system analysis. The storage system included all space and equipment needed to house the materiel and all equipment and labor needed to move materiel within the storage area. Active and inactive storage requirements were considered separately.

b. Outbound flow analysis. Outbound flow included all space, equipment, supplies, and labor needed to process and ship materiel (less preservation and packaging, and container manufacture) beginning at the exit point from the storage system.

c. Inbound flow analysis. Inbound flow included all space, equipment, and labor required to receive and process materiel (less preservation and packaging) up to the point of entry into the storage system.

At this point in the development, a methodology to consider the three geographical depot groupings in terms of space and labor costs was determined.

Special handling and storage requirements such as serial number control for small arms and aircraft engines were also considered at this time.

3. Prepare Conceptual Designs

Initial conceptual designs to develop nominal costs were those needed to accommodate the total system requirements for each flow path.

All depot operations to be costed were divided into two categories for each flow path; those for which alternative concepts were not required (constant cost functions), and those for which alternative concepts were needed (variable cost functions).

a. <u>Constant cost functions</u> were developed and costed first. Methods, equipment, labor, space and supplies requirements were determined and the annual cost for each constant flow path element developed. Total annual costs were reduced to a unit basis to facilitate developing constant costs at other throughput levels.

Low turnover rates in most flow paths diminished the importance of activity-related elements and emphasized the significance of storage and storage-related elements. In addition, some functions involved methods which would not be expected to change significantly over the throughput ranges considered. Thus, the flow path elements determined to be constant cost functions were unloading, checking, inspection, packing, and loading.

b. <u>Variable cost functions</u> requiring analysis of alternative operating concepts were determined to be storage, internal transport, issuing, accumulation, and sortation. Alternative operating concepts for each function were defined and evaluated on an incremental basis.

Investment costs (space and equipment) and annual operating costs (labor and supplies) for each alternative were developed. Simple payback was used to select the most economic alternative foreach flow path element.

Individual elements were combined into a total handling and storage system for each flow path considering practicality of operation and providing the necessary interfaces.

Alternative concepts to satisfy variable cost function requirements were defined and evaluated at the total system throughput level as well as the minimum throughput level. If the same alternative were justified at both ends of the throughput range, a linear relationship between the end points was assumed. If different alternatives were selected at each end of the range, cost/volume region boundaries were established by developing the linear equation for each set of alternatives and solving these equations simultaneously.

4. Develop Input Data for Models

Annual costs for constant and variable cost functions were combined at each level of throughput activity throughout the flow path volume range. The resultant values represent the total annual cost to handle and store the materiel of each flow path at each throughput volume level. These values for each flow path are listed in Exhibit [illegible]

CHAPTER 3
FLOW PATHS

Materials handling flow paths are defined as being groups of items (NSN's) having similar storage and handling requirements. They are closely related to DODMDS product groups and, for the most part, consist of an entire product group or groups. Exceptions are product groups containing cold, hazardous, or security items that can appear in more than one flow path. Additionally, Flow Paths Nos. 10 and 11 divide product groups based on physical characteristics. An individual NSN can appear in one flow path only.

The relationship between flow paths and DODMDS product groups is shown in Figure 3-1. This matrix, based on shipments in hundredweight, shows the percentage of each product group included in each flow path. For modelling purposes, the unit cost for handling and storing materiel in a flow path applies to all product groups, or parts of product groups, existing in that flow path. Conversely, the unit cost for handling and storing materiel in a product group is the weighted average of the unit costs for each flow path in which the product group appears.

The remainder of this Chapter is divided into two Sections. Section A contains a description of the materiel in each flow path, the major characteristics of that materiel, and a general description of the operating parameters used to develop nominal costs.

Major flow path characteristics are summarized in six figures following Section A:

- Figure 3-2, Annual Shipments.
- Figure 3-3, Daily Shipments.
- Figure 3-4, Annual Receipts.
- Figure 3-5, Daily Receipts.
- Figure 3-6, Assets.
- Figure 3-7, Annual Stock Turnover.

DODMDS product group	Flow paths 1	2	3	4	5	6	7	8	9	10	11	TOTAL
101	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
102	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	36.9	61.3	100.0
104	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	4.1	94.3	100.0
111	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
121	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.5	79.5	100.0
131	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
133	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
141	0.0	0.3	8.4	0.0	0.0	0.0	0.0	0.0	0.0	5.3	86.0	100.0
142	0.0	13.6	20.3	0.0	0.6	0.0	0.0	0.0	0.0	41.3	24.0	100.0
149	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.5	98.3	100.0
[illegible]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	97.1	100.0
151	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0

Figure 3-1

Percent of DODMDS Product Group Throughput by Flow Path

152	0,0	0,0	0,0	0,0	100,0	0,0	0,0	0,0	0,0	0,0	0,0	100,0
153	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	63,8	36,2	100,0
154	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	3,9	96,1	100,0
155	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	54,7	45,3	100,0
156	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,4	98,6	100,0
157	0,0	0,0	0,7	0,0	0,0	0,0	0,0	0,0	0,0	0,2	99,1	100,0
161	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,8	97,2	100,0
162	0,0	0,0	0,0	0,0	0,0	100,0	0,0	0,0	0,0	0,0	0,0	100,0
171	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	82,5	17,5	100,0
174	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	25,1	74,9	100,0
191	0,0	0,0	0,0	0,0	100,0	0,0	0,0	0,0	0,0	0,0	0,0	100,0
204	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	75,5	24,5	100,0
221	0,0	0,0	0,0	0,0	100,0	0,0	0,0	0,0	0,0	0,0	0,0	100,0
224	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	100,0	100,0
231	0,0	0,0	0,0	0,0	0,0	0,0	100,0	0,0	0,0	0,0	0,0	100,0
232	0,0	0,0	0,0	0,0	0,0	0,0	100,0	0,0	0,0	0,0	0,0	100,0
241	0,0	0,0	0,0	0,0	0,0	0,0	100,0	0,0	0,0	0,0	0,0	100,0
244	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	97,3	2,7	100,0
264	0,0	0,0	0,0	0,0	0,0	0,0	0,0	100,0	0,0	0,0	0,0	100,0
265	0,0	0,0	0,0	0,0	0,0	0,0	0,0	100,0	0,0	0,0	0,0	100,0
281	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	73,4	26,6	100,0
294	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,2	99,8	100,0
295	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	8,6	91,4	100,0
296	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,2	99,7	100,0
297	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	100,0	100,0
441	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,5	99,4	100,0
442	0,0	0,0	0,4	0,0	0,0	0,0	0,0	0,0	0,0	89,7	9,9	100,0
444	0,0	30,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,8	69,2	100,0
445	0,0	9,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	8,8	82,1	100,0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0,0	0,0	0,0	0,0	0,0	0,4	98,6	100,0

497	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0
534	0.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.8	85.6	100.0
536	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	99.4	100.0
537	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	97.8	100.0
544	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	60.7	37.7	100.0
545	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	89.6	10.4	100.0
581	0.0	0.3	1.7	0.0	0.0	0.0	0.0	0.0	0.0	38.8	59.2	100.0
584	0.0	1.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	9.1	89.5	100.0
586	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	99.1	100.0
587	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	99.9	100.0
611	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	78.2	21.8	100.0
614	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	99.9	100.0
615	0.0	27.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	71.7	100.0
616	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0
617	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0
651	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	97.7	100.0
654	0.0	5.9	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	93.9	100.0
655	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.4	87.6	100.0
671	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	38.0	62.0	100.0
674	1.8	7.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	90.3	100.0
684	0.0	15.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	84.1	100.0
685	0.0	17.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	82.9	100.0
714	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	99.4	100.0
715	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.0	64.0	100.0
844	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0
845	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0
894	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	100.0
895	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	100.0
944	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	99.5	100.0
945	0.0	0.0	3.1	0.0	0.0	0.0	0.0	0.0	0.0	12.9	84.0	100.0

Cost relationships for each flow path at varying throughput levels, as well as among different flow paths, are discussed in Section B. This Section also contains the important findings or insights concerning the DOD Materiel Distribution System that were gleaned from the nominal cost development effort.

A. DESCRIPTIONS AND MAJOR CHARACTERISTICS

1. Flow Path No. 1 -- Cold Storage Items

This flow path consists of all NSN's requiring refrigerated storage (chill and freeze). These NSN's are identified in the data base by their Water Commodity Code which indicates items requiring refrigerated transportation. The DODMDS product groups most prevalent in Flow Path No. 1 are:

654 -- Miscellaneous medical equipment and supplies -- small drugs, film, chemicals, medicated cosmetics.

674 -- Photographic supplies -- film, special paper, and chemicals.

The major characteristics of NSN's in Flow Path No. 1 are:

a. There are no large items.

b. 99 percent of all items are less than one cubic foot per unit of issue.

c. The average weight per unit of issue shipped is 0.23 pounds.

d. The average cube per unit of issue shipped is 0.015 cubic feet.

e. The annual turnover is 1.8.

f. The NSN's in Flow Path No. 1 represent less than one percent of total system assets and daily shipments.

Data characteristics indicate that Flow Path No. 1 is primarily a bin-type operation. Since it has little significance in the total DOD system workload in terms of inventory and activity, cost values for Flow Path No. 1 are based on those developed for Flow Path No. 11. Major differences in flow path cost factors between No. 1 and No. 11 are:

a. Space cost factors. Cold storage space is 2.2 times as costly as general purpose storage space.

b. Labor cost factors. Working in freeze and chill spaces results in a premium factor being placed on labor. This premium is caused by the need to wear special clothing, more inefficient working in cold spaces, and the need for extra Personal Fatigue and Delay (PF&D) allowance. Normal practice is to add 20 percent to regular warehouse labor cost for work in cold spaces. Flow Path No. 11 labor costs were increased by a factor of 20 percent to estimate labor costs for Flow Path No. 1.

2. Flow Path No. 2 -- Hazardous Storage Items

This flow path consists of all NSN's identified as requiring special handling and/or storage treatment because of their hazardous nature. These items are identified in the data base by their type of cargo code which indicates hazardous cargo items for transport. DODMDS product groups appearing in this flow path in significant amounts are:

142 -- Missile reparables, large.

494 -- Miscellaneous shop and industrial items -- consumables, medium (10-50 pounds per unit of issue).

495 -- Miscellaneous shop and industrial items -- consumables, large.

496 -- Miscellaneous shop and industrial items -- consumables, small.

534 -- Hardware and related items, medium/large (over ten pounds per unit of issue).

584 -- Communication electronics, other, medium (over ten pounds per unit of issue).

615 -- Batteries, fuel cells, etc.

654 -- Miscellaneous medical equipment and supplies -- small.

674 -- Photographic supplies.

684 -- Chemicals, paints, petroleum products -- small.

685 -- Chemicals, paints, petroleum products -- large.

Major characteristics of Flow Path No. 2 items are:

a. 99 percent of active asset cube is represented by small items.

b. 99 percent (by cube) of total assets are active.

c. Distribution of NSN size within the small category of active assets is:

Unit of issue cube range	Percent of total cube
0-1	43
1-8	27
8-18	30
Total	100

d. The average weight per unit of issue shipped is 15.64 pounds.

e. The average cube per unit of issue shipped is 0.41 cubic feet.

f. The annual turnover is 1.9.

g. Flow Path No. 2 represents less than one percent of total system assets and daily issues.

Because of their relative insignificance in the total DODMDS, the cost relationships for Flow Path No. 2 were based on those developed for Flow Path No. 9, Subsistence. The major characteristics of Flow Path No. 2, as shown above, indicate that handling and storage requirements are oriented more towards a case and pallet operation than a bin operation.

Because of the differences in stock turnover between Flow Paths Nos. 2 and 9, total costs for Flow Path No. 2 were developed considering asset-related and throughput-related costs separately.

Significant differences between Flow Path No. 2 cost factors and those for Flow Path No. 9 include:

a. Space cost factors. The space cost for hazardous storage is 1.015 times that for general purpose storage.

b. Equipment cost factors. Due to the need for explosion-proof equipment, the cost for handling equipment was increased by 30 percent.

c. Labor cost factors. A ten percent premium was placed on labor costs to reflect the additional caution required when handling hazardous materiel.

3. Flow Path No. 3 -- Security Storage Items

This flow path consists of all NSN's identified as requiring vault-type storage and special handling for security purposes. The pilferage/security code in the

DODMDS catalog file was used to identify these items. Commonplace items, such as small office machines, tools, etc., that may require storage in an enclosure separate from other materiel, but do not require vault-type storage, are not included in this flow path. Classified and highly valuable items are included. DODMDS product groups included in Flow Path No. 3 in significant amounts are:

102 -- Guns over 75 mm and major components.

104 -- Arms and fire control -- parts.

121 -- Fire control -- reparables.

141 -- Missiles -- reparables -- small.

142 -- Missiles -- reparables -- large.

144 -- Missile parts -- small.

157 -- Aircraft structural parts -- consumables -- small.

544 -- Construction materiels -- small.

581 -- Communications electronics -- reparables.

995 -- Miscellaneous -- large (collectors' items).

Significant characteristics of items in Flow Path No. 3 are:

a. Large items represent 87 percent of the active asset cube.

b. Large items represent only three percent of the units of issue in inventory.

c. 80 percent of these large items are missiles and missile components.

d. 69 percent of small items are less than one cubic foot per unit of issue.

e. Annual turnover rate is 1.1.

f. Materiel in Flow Path No. 3 represents less than one percent of the total system in terms of assets and throughput.

Based on the above item characteristics and the relative insignificance of Flow Path No. 3 in the overall DODMDS, costs for this flow path were developed using Flow Paths Nos. 7 and 11 as guides.

For cost development purposes, large items were treated as in Flow Path No. 7, Vehicles, and small items as in Flow Path No. 11, All Other, Small. Space costs developed for Flow Paths Nos. 7 and 11 were increased by 19 percent to reflect the special construction required for security storage.

To account for annual turnover differences between Flow Path No. 3 and Nos. 7 and 11, asset- and throughput-related costs were developed separately.

4. Flow Path No. 4 -- Small Arms

All of DODMDS commodity 101 is included in this flow path. Fire arms and accessories up to 75 mm are included.

Major characteristics of Flow Path No. 4 are:

a. 89 percent of the NSN's representing 85 percent of the cube in inventory are small items.

b. 69 percent of the small item cube represents items with a unit of issue cube of less than one cubic foot.

c. Annual turnover is 0.4.

d. Materiel in Flow Path No. 4 represents less than one percent of total system assets and throughput.

This flow path is also of little significance in the total DOD Materiel Distribution System and was costed on a statistical basis.

Items listed as large were treated in the same manner as those in Flow Path No. 9, since the large segment of Flow Path No. 4 is basically a case and pallet operation. Items listed as small were treated in the same manner as those in Flow Path No. 11, since the small segment of Flow Path No. 4 is similar to a bin operation for repair parts.

Asset- and throughput-related costs were developed separately to reflect the difference in turnover between Flow Path No. 4 and Nos. 9 and 11. Based on an examination of DOD documentation regarding receipt, storage, and issue of sensitive items (weapons), plus field observations of storage and handling operations, a labor cost of two times that used for the base flow paths was used for Flow Path No. 4. This labor cost increase reflects the additional cost needed to satisfy the serial number control and special security requirements.

To account for the special construction required for small arms storage, base flow path space costs were increased by 19 percent.

5. <u>Flow Path No. 5 -- Ships, Boats, Aircraft, Railway Equipment</u>

All items in the following DODMDS product groups are included in this flow path:

151 -- Fixed wing, reparables (complete aircraft only).

152 -- Rotary wing reparables (complete aircraft only).

191 -- Ships and boats (primarily small craft).

221 -- Railway equipment, reparables (locomotives, railcars, large right-of-way maintenance equipment, and major accessories).

Nearly 100 percent of items in this flow path are large. Other important characteristics are:

a. Annual turnover is 1.1.

b. Because of the item size (7,000 pounds per unit of issue shipped, 1,248 cubic feet per unit of issue shipped), the daily shipments of NSN's in this flow path represent 7.5 percent of the total system cube and weight shipments, respectively. In terms of number of issues and number of units of issue shipped, Flow Path No. 5 is insignificant within the total system.

Cost development for Flow Path No. 5 was performed statistically, based on the costs from Flow Path No. 7, but omitting the cost of space, since all assets are assumed to be in open storage. No separate costing was made for the small category due to the relatively insignificant quantities. All computations were based on inventory and throughput requirements separately to reflect the difference in turnover between Flow Paths Nos. 5 and 7.

6. Flow Path No. 6 -- Aircraft Engines

All items in DODMDS Product Group 162 (aircraft engines and major components, large -- over 50 pounds per unit of issue) -- are included in this flow path.

Major characteristics of items in Flow Path No. 6 include:

a. Large items represent 59 percent of active asset cube but only 20 percent of the NSN's in inventory.

b. Annual turnover is 5.0.

c. The average weight per unit of issue shipped is 1,260 pounds.

d. The average cube per unit of issue shipped is 85.7 cubic feet.

e. Flow Path No. 6 represents less than one percent of total system asset cube and 2.6 percent of total system shipment cube.

The cost development for this flow path was accomplished in two parts, using different bases. Those items listed as large were evaluated on a unit of issue basis with the cost curve predicated on inventory and throughput costs derived from Flow Path No. 7. The need for individual serial number access was accounted for by considering the stackability of engine containers and use of narrower aisles than those needed in Flow Path No. 7.

Small items are evaluated separately, using Flow Path No. 9 as the guide.

Handling- and storage-related costs were developed separately to account for the difference in annual turnover between Flow Path No. 6 and Flow Paths Nos. 7 and 9.

7. Flow Path No. 7 -- Vehicles

All items in the following DODMDS product groups are included in this flow path:

231 -- Wheeled vehicles -- autos, trucks, trailers, motorcycles.

232 -- Combat tracked vehicles -- tanks, half-tracks, tracked self-propelled weapons.

241 -- Tractors and construction equipment -- large tractors, cranes, earth movers, road-clearing equipment, and construction equipment accessories.

Flow Path No. 7 represents a significant portion of the total DOD Materiel Distribution System. Vehicles comprise about 14 percent of the total system assets and about 15 percent of the total system shipment weight.

Storage and handling costs for this flow path were developed in detail and these costs used as guidelines for costing other flow paths of lesser significance.

For cost analysis purposes, Flow Path No. 7 was divided into two parts -- large and small. Since the "small" segment represents less than one percent of the total flow path cube, emphasis was placed on large. All development of space, equipment, and labor cost was done on a unit of issue basis, using operational time standards obtained at existing locations handling vehicles in significant quantities, and supplemented by synthesized standards, where required.

Small items were costed on a statistical basis, using the results of Flow Path No. 11 as a guide.

Large and small costs were combined to obtain total costs at various levels of throughput.

Materiel in Flow Path No. 7 requires a bulk unit load handling and storage system. Handling functions are accomplished primarily by towing with tractors and small trucks with some crane and forklift handling supplemented where needed. Storage is all indoors utilizing stacking frames where appropriate to effect space savings. Because costs in this flow path are dominated

by space requirements, alternatives using stacking frames were considered where possible. Due to size and physical characteristic differences of vehicle types, stacking two, three, and four tiers high, as well as one-high floor storage, resulted from our analysis.

Integrity of inventory lots was maintained providing access to each NSN at all throughput levels.

Small daily throughput volumes below the ten depot throughput level resulted in minimum crew size requirements in individual work centers. This phenomenon had the effect of creating a constant labor cost at the lower end of the cost curve.

8. Flow Path No. 8 -- Tires

All items in the following DODMDS product groups are included in this flow path:

264 -- Tires and tubes, nonaircraft (solid and pneumatic).

265 -- Tires and tubes, aircraft.

This flow path is relatively insignificant in that it represents only about one percent of total system activity and inventory. Annual turnover is 1.5.

Cost values are based on costs from Flow Path No. 9.

This relationship between Flow Paths Nos. 8 and 9 was established on the basis of cube relation at both ends of the throughput scale -- 1 and 40 depots. Storage-related costs were based on total asset cube, and throughput-related costs were based on issue cube.

Large items were combined with small items for cost curve development purposes because they represent only about five percent of the total number of NSN's

and less than one percent of the total number of units of issue in inventory, and about two and one-half percent of the units of issue shipped.

9. Flow Path No. 9 -- Subsistence

All subsistence items in DODMDS Product Groups 894 (Troop Issue Subsistence) and 895 (DICOMS) are included in Flow Path No. 9. Toiletries, cosmetics, feed and fodder, tobacco, and nonperishable subsistance are included.

This flow path is a significant one, as it represents about 27 percent of the total system shipment weight. Asset cube is relatively low (about one percent of the system total). Subsistence has the highest annual turnover rate (5.6) of all the flow paths.

All items in Flow Path No. 9 are in the small category and represent the requirements of a case and pallet operation. Movement between work centers is almost entirely unit loads on pallets. Handling to and from storage is accomplished using narrow-aisle forklifts. Storage in five-high pallet racks is economically justified at all throughput levels.

Order selection is by requisition in four daily batches, one for each of three issue priority groups and an additional batch for emergencies. The picking method selected is full-case picking to pallets on carts pulled by a tractor. Accumulation by consignee storage is in four-high pallet racks.

An interbuilding transfer function is required at the total system throughput level as the total space requirement exceeds one million square feet.

10. Flow Path No. 10 -- All Other Large

All items, in all DODMDS product groups, which are not included in one of the preceding nine flow paths, and which have at least one dimension greater than four feet or unit of issue cube greater than 64 cubic feet, are included in Flow Path No. 10. These items are primarily consumables and can be generally divided into four groups by their physical characteristics:

Long items -- pipe, bars, rods, structural members.

Sheet items -- plywood, sheet metal, plate, panels.

Bulk items -- NSN's having a generally rectangular shape with all three dimensions (height, length, depth) being greater than four feet.

Shapes -- Items having one large (greater than eight feet) dimension and two dimensions less than four feet. Such items as lumber, structural shapes with a significant cross-section, and aircraft wing members fall into this group.

Flow Path No. 10 represents almost 46 percent of total system asset cube and about 24 percent and 16 percent of total system shipment cube and weight, respectively. Activity in terms of issues is low (only 1.4 percent of total system shipments) as is the annual turnover rate of 0.7.

For analysis purposes, items in this flow path were segregated by their physical characteristics into four groups as described above. Individual handling and storage systems for each of the four groups were conceptualized and costed using the evaluation of alternatives procedure.

Handling between work centers and to and from storage is accomplished using overhead cranes, sideloaders, and forklift trucks. Storage in cantilever racks and floor storage were the primary methods selected after evaluation of alternatives.

Due to the unique physical characteristics of items in Flow Path No. 10, the number of alternatives evaluated was limited. For most work centers the economically justified system at the total system volume

level is the same as that at the minimum throughput level.

11. Flow Path No. 11 -- All Other Small

All items, in all DODMDS product groups, which are not included in Flow Paths Nos. 1 through 10, are included in this flow path. These items have no dimension greater than four feet and are considered to be palletizable. These items are all candidates to be stored in bins and/or pallet rack configurations.

This flow path is the dominant one in terms of shipments, representing 91 percent of total system daily issues, 34 percent of daily shipment cube, and 33 percent of daily shipment weight. The asset cube of Flow Path No. 11, approximating 35 percent of the DODMDS total, is also of major significance. The annual turnover rate is 0.6.

Flow Path No. 11 represents the requirements of a bin, case, and pallet materials handling and storage system. Some mechanization is economically justified at the higher end of the throughput scale. At the lower end, most requirements are satisfied with manual systems.

For less-than-pallet quantity lot sizes of small items, standard bins to 40 feet in height are employed using a man-ride stacker system to select and replenish materiel.

For lot sizes of one to ten pallets, an automatic stacker/retriever system is justifed for storage and movement within the storage area at the higher throughput levels. Conventional forklift and pallet rack systems were selected for the lower throughput levels.

Floor storage is used for large lot sizes (greater than ten pallets per NSN) with handling to and from storage using narrow-aisle forklift trucks.

Horizontal travel is accomplished using both draglines and tractor-trains.

Case and bin items are picked individually by requisition, and sorted prior to packing, using tilt-tray sorting units. At lower throughput levels, conveyor sorting is used. Requisitions calling for one pallet or more of a single NSN are routed directly from storage to packing without the need for sortation.

Four batches of requisitions are picked daily, one for each issue priority group and one for emergencies.

Different handling and storage method alternatives were economically justified at various throughput levels for storage, full-case picking, horizontal transport, and sortation.

B. COST RELATIONSHIPS AND FINDINGS

The direct variable segment of nominal depot costs for each flow path, the relationship of these costs to throughput volumes, and conclusions drawn from the cost development are discussed in this Section.

1. Cost versus Throughput in Hundredweight

Because costs used in the modelling process are expressed in terms of dollars per hundredweight, all costs developed for flow paths were reduced to this basis. It is important to note that handling and storage costs were not developed in these terms as weight is not a particularly meaningful measure of warehousing cost or activity. Depending upon the flow path involved, costs were developed in terms of cube handled and stored, or units of issue processed. The final step in cost development was to convert these costs to the weight basis needed.

Figure 3-8 is a summary showing total annual cost and throughput in terms of hundredweight for each flow path at the maximum (total system) and minimum (40 depot) levels of activity. In each case, the unit cost per hundredweight is calculated.

Flow path		NSN's[a]		Issues[b]		Units of issue[b]		Cube[b]		Weight[b]	
No.	Description	No.	%	No.	%	No. (1,000)	%	No. (1,000 cubic feet)	%	No. (1,000 pounds)	%
1	Cold	292	.0	57,011	.2	2,713	.1	41	.0	624	.0
2	Hazardous	1,051	.1	118,440	.4	6,118	.3	2,523	.9	95,499	2.1
3	Security	2,162	.2	39,419	.1	2,669	.1	1,732	.7	12,678	.3
4	Small arms	1,231	.1	22,658	.1	1,187	.1	957	.4	18,688	.4
5	Ships/boats, etc.	225	.0	2,307	.0	17	.0	21,719	7.7	121,665	2.7
6	Aircraft engines	1,793	.1	55,730	.2	83	.0	6,768	2.5	99,374	2.2
7	Vehicles	1,399	.1	14,619	.1	59	.0	36,492	13.6	620,789	13.6
8	Tires	1,418	.1	154,942	.5	1,287	.1	6,554	2.4	56,582	1.2
9	Subsistence	2,133	.1	2,142,974	7.1	708,668	34.9	42,334	15.8	1,410,250	31.0
10	All other -- large	29,856	2.0	435,512	1.4	13,269	.7	61,306	22.9	697,043	15.3
11	All other -- small	1,425,633	97.2	27,024,360	89.9	1,293,833	63.7	88,916	33.1	1,423,216	31.2
	Total	1,467,193	100.0	30,067,972	100.0	2,029,903	100.0	269,342	100.0	4,556,408	100.0

Source: [a]DODMDS Reports C1.3A(M) and C1.4B.
[b]DODMDS Reports C1.3B(M) and C1.3B(N).

Figure 3-2

Annual Shipments by Flow Path

Flow path No.	Flow path Description	NSN's[a] No.	NSN's[a] %	Issues[b] No.	Issues[b] %	Units of issue[b] No. (1,000)	Units of issue[b] %	Cube[b] No. (1,000 cubic feet)	Cube[b] %	Weight[b] No. (1,000 pounds)	Weight[b] %
1	Cold	292	.0	219	.2	10.40	.1	.2	.0	2	.0
2	Hazardous	1,051	.1	452	.4	23.40	.3	9.6	1.0	366	2.2
3	Security	2,162	.2	148	.1	10.20	.1	6.6	.7	49	.3
4	Small arms	1,231	.1	76	.1	4.10	.1	3.1	.3	64	.4
5	Ships/boats, etc.	225	.0	8	.0	.06	.0	74.9	7.5	420	2.5
6	Aircraft engines	1,793	.1	209	.2	.30	.0	25.7	2.6	378	2.3
7	Vehicles	1,399	.1	57	.1	.20	.0	143.1	14.3	2,434	14.7
8	Tires	1,418	.1	549	.5	4.50	.1	23.2	2.3	200	1.2
9	Subsistence	2,133	.1	6,801	6.0	2,249.70	30.8	134.4	13.5	4,477	27.1
10	All other -- large	29,856	2.0	1,669	1.4	50.80	.7	234.9	23.6	2,671	16.2
11	All other -- small	1,425,633	97.2	103,541	91.0	4,957.20	67.8	340.8	34.2	5,453	33.1
	Total	1,467,193	100.0	113,729	100.0	7,310.86	100.0	996.5	100.0	16,514	100.0

Source: [a]DODMDS Reports C1.3A(M) and C1.4B.
[b]DODMDS Reports C1.3B(M) and C1.3B(N) factored by working days[c] per year.

[c]Days per year by flow path used as follows to factor out nonstudy depot activity:

Flow path	Days per year
1,2,3,10,11	261
4	290
5	290
6	263
7	255
8	283
9	315

Figure 3-3

Daily Shipments by Flow Path

Flow path No.	Flow path Description	No. of receipts (1,000)	%	Cubic feet received (1,000 cubic feet)	%
1	Cold	3.3	.0	171	.1
2	Hazardous	11.2	.2	2,329	.9
3	Security	22.6	.4	630	.2
4	Small arms	14.4	.2	561	.2
5	Ships/boats, etc.	1.0	.0	10,935	4.3
6	Aircraft engines	50.7	.9	5,108	2.0
7	Vehicles	14.5	.3	43,590	17.0
8	Tires	28.3	.5	8,044	3.1
9	Subsistence	154.0	2.7	28,430	11.1
10	All other -- large	272.4	4.8	88,457	34.6
11	All other -- small	5,131.0	90.0	67,749	26.5
	Total	5,703.4	100.0	256,004	100.0

[a] Source: DODMDS Report B1.6.

Figure 3-4

Annual Receipts by Flow Path[a]

Flow path No.	Flow path Description	No. of receipts	%	Cubic feet received (1,000 cubic feet)	%
1	Cold	11	.1	.7	.1
2	Hazardous	41	.2	9.3	.9
3	Security	89	.4	2.5	.2
4	Small arms	55	.2	2.2	.2
5	Ships/boats, etc.	3	.0	43.6	4.3
6	Aircraft engines	202	.9	20.4	2.0
7	Vehicles	56	.2	173.7	17.0
8	Tires	113	.5	32.0	3.1
9	Subsistence	613	2.7	11[illegible].3	11.1
10	All other -- large	1,082	4.8	352.4	34.6
11	All other -- small	20,440	90.0	270.0	26.5
	Total	22,705	100.0	1,020.1	100.0

[a]Source: DODMDS Report B1.6 factored by 251 working days per year.

Figure 3-5

Daily Receipts by Flow Path[a]

Flow path		Active assets[a]				Inactive assets[b]				Total assets			
		NSN's		Cube		NSN's		Cube		NSN's		Cube	
No.	Description	No.	%	1,000 cubic feet	%	No.	%	1,000 cubic feet	%	No.	%	1,000 cubic feet	%
1	Cold	292	.0	28	.0	12	.0	-	.0	304	.0	28	.0
2	Hazardous	1,051	.1	1,248	.4	375	.03	142	.0	1,426	.0	1,390	.2
3	Security	2,162	.2	1,490	.5	1,470	.11	116	.0	3,632	.1	1,606	.2
4	Small arms	1,231	.1	1,801	.5	419	.03	67	.0	1,650	.1	1,868	.3
5	Ships, boats, etc.	225	.0	16,462	4.6	243	.02	2,016	.6	468	.0	18,478	2.9
6	Aircraft engines	1,793	.1	1,294	.4	428	.03	149	.1	2,221	.1	1,443	.2
7	Vehicles	1,399	.1	82,367	24.7	1,319	.10	7,742	2.5	2,718	.1	90,109	13.9
8	Tires	1,418	.1	3,878	1.2	361	.03	56	.0	1,779	.1	3,934	.6
9	Subsistence	2,133	.1	6,074	1.8	164	.01	4	.0	2,297	.1	6,078	.9
10	All other -- large	29,856	2.0	86,568	26.0	25,739	1.94	210,319	67.0	55,595	2.0	296,887	45.8
11	All other -- small	1,425,633	97.2	132,897	39.9	1,299,378	97.70	93,467	29.8	2,725,011	97.4	226,364	35.0
	Total	1,467,193	100.0	334,107	100.0	1,329,908	100.00	314,078	100.0	2,797,101	100.0	648,185	100.0

Source: [a]DODMDS Reports: C1.3A(M) -- Active Assets. C1.4B -- Assets inactive due to condition code.
[b]DODMDS Report C1.4A -- Inactive assets (number of shipments during DODMDS study year).

Figure 3-6

Assets by Flow Path

Flow path No.	Description	Shipment cube (1,000 cubic feet) Daily[a]	Annual[b]	Active assets[c] (1,000 cubic feet)	Turn-over[d]
1	Cold	.2	50.2	28	1.8
2	Hazardous	9.6	2,409.6	1,248	1.9
3	Security	6.6	1,656.6	1,490	1.1
4	Small arms	3.1	778.1	1,801	0.4
5	Ships/boats, etc.	74.9	18,799.9	16,462	1.1
6	Aircraft engines	25.7	6,450.7	1,294	5.0
7	Vehicles	143.1	35,918.1	82,367	0.4
8	Tires	23.2	5,823.2	3,878	1.5
9	Subsistence	134.4	33,734.4	6,074	5.6
10	All other -- large	234.9	58,959.9	86,568	0.7
11	All other -- small	340.8	85,540.8	132,897	0.6
	Total	996.5	250,121.5	334,107	0.7

Source: [a]DODMDS Reports C1.3B(M) and C1.3B(N) factored by working days per year.

[b]Daily volume x 251 working days per year.

[c]DODMDS Reports C1.3A(M) and C1.4B.

[d]Annual shipment cube ÷ active asset cube.

Figure 3-7

Annual Stock Turnover by Flow Path

Flow path	Total system throughput level: Throughput (1,000 cwt.)	Total annual cost[a] ($1,000)	Unit cost ($/cwt.)	40 depot throughput level: Throughput (1,000 cwt.)	Total annual cost[a] ($1,000)	Unit cost ($/cwt.)	Ratio[b]
1	6	537	89.50	0.15	27	180.0	2.01
2	918	720	0.78	23	44	1.91	2.45
3	122	599	4.91	3.1	75	24.19	4.93
4	162	1,569	9.69	4.1	51	12.44	1.28
5	1,053	1,902	1.81	26	142	5.46	3.02
6	948	3,359	3.54	24	189	7.88	2.23
7	6,208	13,157	2.12	155	833	5.37	2.53
8	502	1,686	3.36	12.6	76	6.03	1.79
9	11,237	6,971	0.62	281	255	0.91	1.47
10	6,703	81,096	12.10	168	5,184	30.86	2.55
11	13,687	96,740	7.09	342	2,911	8.51	1.20
Total	41,546	208,337	5.01	1,038.95	9,787	9.42	1.88

[a]Depot grouping (Region) II values.
[b]Ratio of unit cost at 40 depot level to unit cost at total system level.

Figure 3-8

Cost/Weight Throughput Relationships

For each flow path, the unit cost at the maximum volume level is less than the unit cost at the minimum level. This unit cost relationship indicates that an economy of scale is introduced as throughput increases.

The relationships of annual costs to throughput weight are shown graphically in Figure 3-9. Flow paths having steep slopes indicate that they are sensitive to throughput changes. Because of relatively low annual stock turnover rates for most flow paths, this sensitivity of cost to throughput is dependent upon both handling and storage requirements, not handling alone.

2. Cost versus Throughput in Cubic Feet

Unit costs in terms of dollars per cubic foot of throughput are more meaningful than those in terms of weight because the density of materiel in each flow path is considered. Figure 3-10 is a summary showing total annual cost and throughput in terms of cubic feet for each flow path at the maximum and minimum levels of throughput volume. Unit costs per cubic foot shipped are calculated for each flow path.

Costs in terms of cube are shown as a basis of comparison against the costs in terms of weight. The range of unit costs per cubic foot among flow paths is significantly smaller than that for unit costs per hundredweight.

Because materiel density is considered, and costs in terms of cube handled and stored are a better measure of warehousing cost, the unit costs shown in Figure 3-10 more accurately reflect the degree of difficulty in handling and storage than do the weight-based costs discussed above.

3. Economies of Scale

Economies of scale introduced by more effective handling and storage operations as volume increases are best depicted by plotting unit costs versus throughput over the entire throughput range. Figure 3-11 shows these graphs for the four base flow paths (Nos. 7, 9, 10,

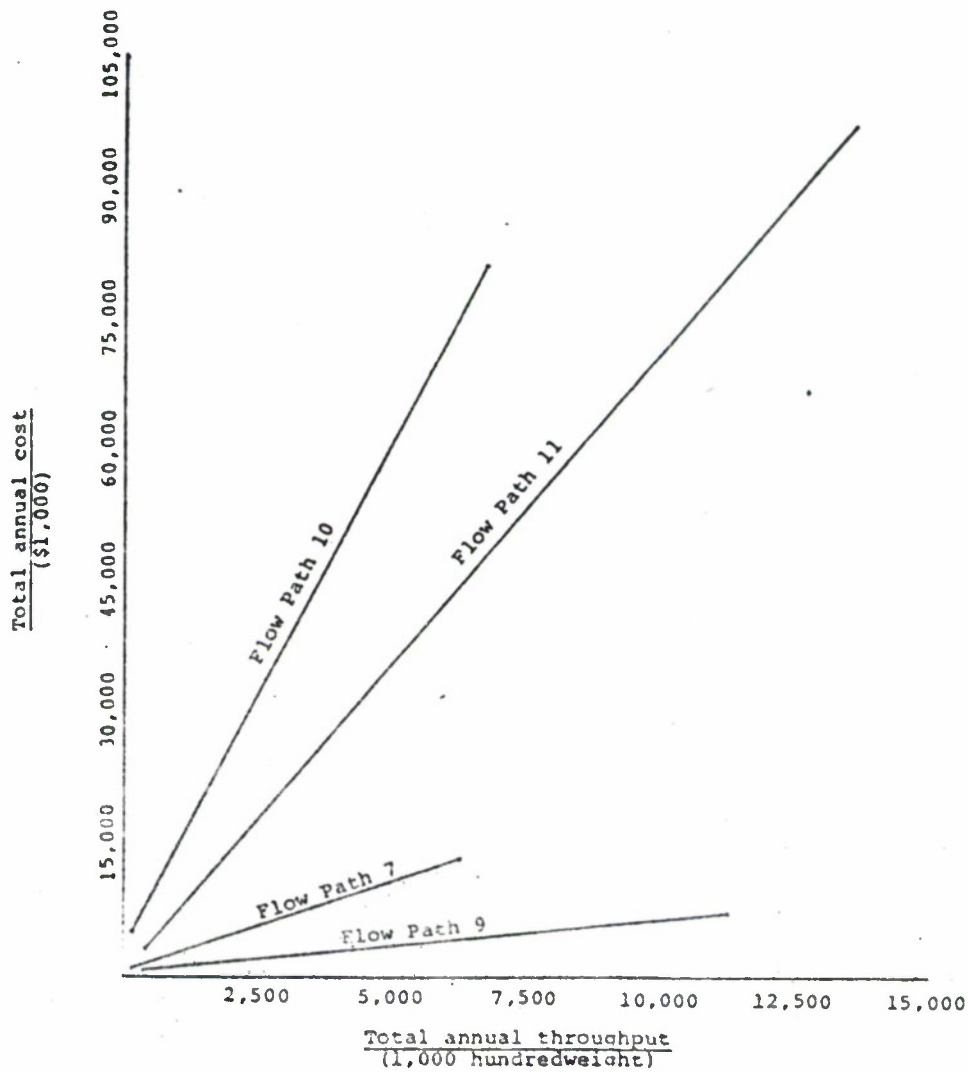

Figure 3-9

Cost/Weight Throughput Cost Curves

Flow path	Total system throughput level: Throughput (1,000 ft.^{3})	Total annual cost[a] ($1,000)	Unit cost ($/ft.^{3})	40 depot throughput level: Throughput (1,000 ft.^{3})	Total annual cost[a] ($1,000)	Unit cost ($/ft.^{3})
1	40	537	13.43	1	27	27.0
2	2,399	720	0.30	60	44	0.73
3	1,659	599	0.36	41	75	1.83
4	784	1,569	2.00	20	51	2.55
5	18,807	1,902	0.10	470	142	0.30
6	6,447	3,359	0.52	161	189	1.17
7	35,919	13,157	0.37	898	833	0.93
8	5,834	1,686	0.29	146	76	0.52
9	33,722	6,971	0.21	843	255	0.30
10	58,977	81,096	1.38	1,474	5,184	3.52
11	85,544	96,740	1.13	2,139	2,911	1.36
Total	250,132	208,337	0.83	6,253	9,787	1.57

[a] Depot grouping (Region) II values.

Figure 3-10

Cost/Cube Throughput Relationships

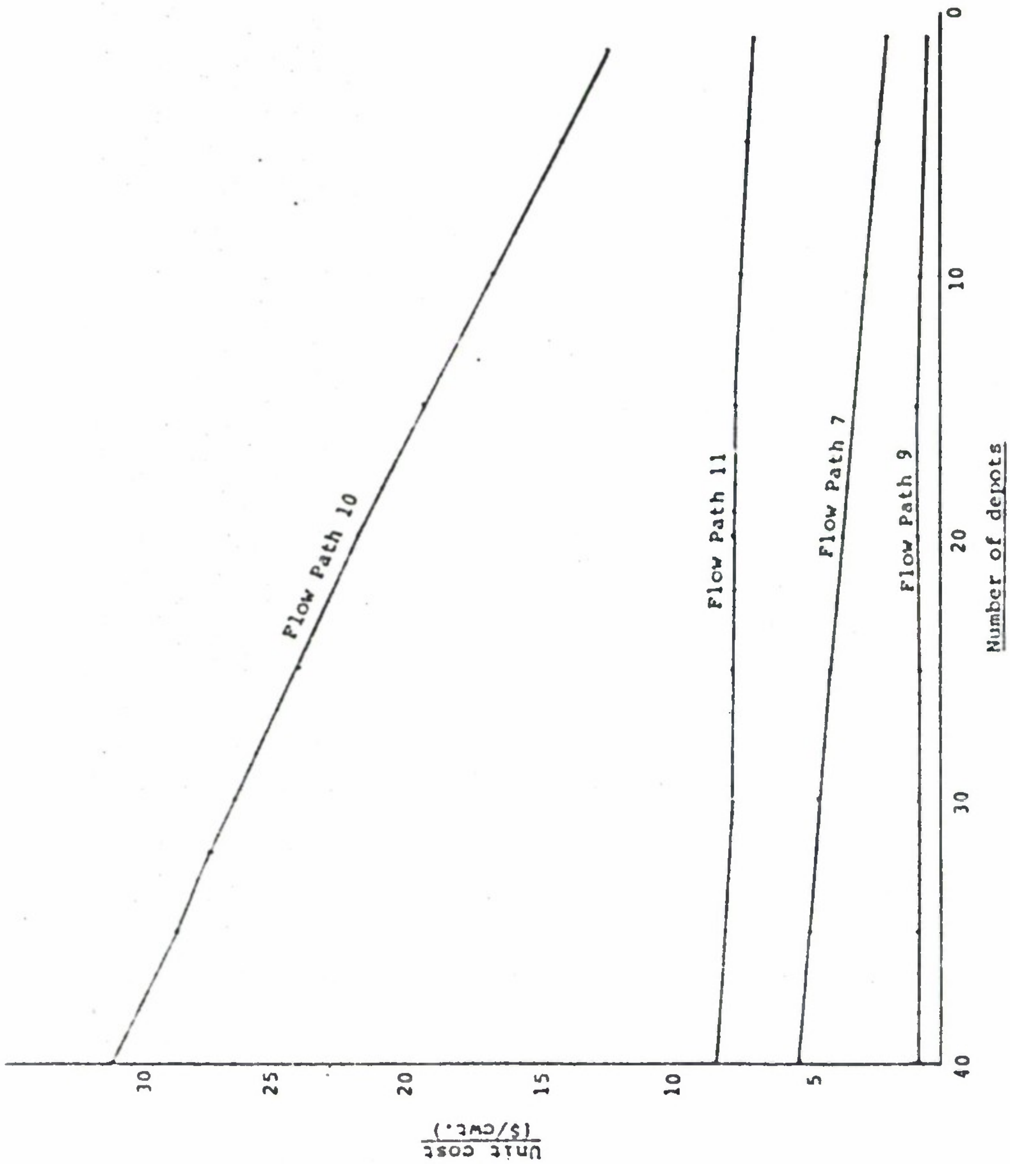

Figure 3-11

Unit Cost/Throughput Relationships

and 11). In this Figure, throughput is expressed in terms of numbers of depots to allow equal examination of each flow path.

Flow Paths Nos. 7 and 10 have the steepest slopes and exhibit the greatest economies of scale. These economies of scale are due not to increasing use of mechanization, but to better utilization of labor, equipment, and space as throughput volume increases. Both of these flow paths contain large, bulky items requiring specialized equipment such as cranes for handling. A significant investment for this equipment is needed even at the lowest volume level. Additionally, fixed crew sizes to operate the equipment are needed regardless of the amount of materiel handled. This initial investment for labor and equipment, combined with the poorer utilization of space at low-volume levels due to small lot sizes, results in high unit costs at the low end of the throughput scale. As throughput increases, equipment, labor, and space are better utilized, and unit costs decrease.

Flow Paths Nos. 9 and 11 require more conventional handling and storage concepts such as bins, racks, and forklift trucks. Since large initial costs are not required, economies of scale for these flow paths are more dependent upon increased use of, and sophistication of, mechanization as throughput increases.

Substantial labor savings through mechanization are not economically justified for these flow paths even at the highest volume levels; thus, significant economies of scale do not result from the analysis.

Flow Path No. 11 required a system change for practical reasons at the 22 depot level causing the slight increase in unit cost at this point. A sorting conveyor system which was economical in the 40 to 22 depot range became impractical at volumes above this range. The system required to physically handle the sorting workload at higher volumes has a higher unit cost than the system it replaced. The curve for the sortation work center is discontinuous at the 22 depot throughput level.

4. Cost Mix

Figures 3-12 and 3-13 show the annual cost mix of space, equipment, labor, and supplies for each flow path at the maximum and minimum throughput levels. These Figures illustrate two points which are important concerning the cost development and the DODMDS itself. First, space cost is the dominant cost element. This is due to the low annual turnover rate in most flow paths and the large quantity of inactive materiel reflected in the Study Group data base. Second, the percent of labor cost at the minimum activity level is lower than that at the total system level. Conversely, the percent of equipment cost at the minimum throughput level is higher than that at the maximum level. This change in cost mix indicates that more and/or sophisticated mechanization does not become economically justified at the higher throughput levels. This is due partly to the low annual turnover rates and partly to the one-shift-per-day criterion used. This criterion reduces mechanization utilization and makes economic justification more difficult.

5. Findings

The nominal cost development effort required identification of DOD wholesale distribution system attributes in terms of operational requirements and cost sensitivities. The major findings resulting from this effort are:

a. System Attributes. The DODMDS is primarily a storage system. Materials handling is secondary to storage in terms of requirements and costs. The overall system annual stock turnover rate of 0.7 is very low relative to distribution systems in the civilian public and private sectors. This turnover rate only considers active assets. It is considerably smaller if computed using the combined active and inactive asset volume.

Flow path	Space: Annual cost ($1,000)	Space: Percent of total	Equipment: Annual cost ($1,000)	Equipment: Percent of total	Labor: Annual cost ($1,000)	Labor: Percent of total	Supplies: Annual cost ($1,000)	Supplies: Percent of total	Total annual cost ($1,000)
1	240	44.7	78	14.5	209	38.9	10	1.9	537
2	72	10.1	68	9.4	569	79.0	11	1.5	720
3	280	46.7	99	16.6	199	33.2	21	3.5	599
4	356	22.7	215	13.7	971	61.9	27	1.7	1,569
5	-	-	710	37.3	766	40.3	426	22.4	1,902
6	2,251	67.0	386	11.5	467	13.9	255	7.6	3,359
7	8,742	66.5	1,525	11.6	1,910	14.5	980	7.4	13,157
8	182	10.8	147	8.7	1,328	78.8	29	1.7	1,686
9	754	10.8	607	8.7	5,492	78.8	118	1.7	6,971
10	45,831	56.6	18,680	23.0	14,958	18.4	1,627	2.0	81,096
11	28,392	29.3	20,506	21.2	45,290	46.9	2,553	2.6	96,741
Total	87,100	41.9	43,021	20.6	72,159	34.6	6,057	2.9	208,337

[a] Depot Grouping (Region) II cost values.

Figure 3-12

Annual Cost[a] Elements -- Total System Throughput Level

Flow path	Space: Annual cost ($1,000)	Space: Percent of total	Equipment: Annual cost ($1,000)	Equipment: Percent of total	Labor: Annual cost ($1,000)	Labor: Percent of total	Supplies: Annual cost ($1,000)	Supplies: Percent of total	Total annual cost ($1,000)
1	10	37.1	8	29.6	8	29.6	1	3.7	27
2	5	11.4	11	25.0	27	61.3	1	2.3	44
3	27	35.3	23	31.3	23	31.1	2	2.3	75
4	11	20.7	14	28.4	25	49.2	1	1.7	51
5	-	-	39	27.5	91	64.0	12	8.5	142
6	103	55.0	20	10.4	60	31.5	6	3.1	189
7	445	53.4	103	12.4	260	31.2	25	3.0	833
8	9	11.8	17	22.4	48	63.2	2	2.6	76
9	31	12.2	58	22.7	160	62.7	6	2.4	255
10	2,866	55.4	1,811	34.9	463	8.9	44	0.8	5,184
11	710	24.4	1,160	39.8	974	33.5	67	2.3	2,911
Total	4,217	43.0	3,264	33.4	2,139	21.9	167	1.7	9,787

[a] Depot Grouping (Region) II cost values.
[b] Forty depot throughput level.

Figure 3-13

Annual Cost[a] Elements -- Minimum[b] Throughput Level

Structuring system requirements by flow path also revealed insights into the nature of the DODMDS. Small items, predominantly bin-type items and cases suitable for palletization, represent 97 percent of all NSN's. 91 percent of the active asset cube is comprised of Vehicles, Small Items, and Large Items (Flow Paths Nos. 7, 10, and 11). Other flow paths are insignificant in terms of inventory.

Large items (Flow Path No. 10) account for 67 percent of the total inactive asset cube.

System activity consists primarily of Vehicles, Subsistence, and Small Items. These three flow paths represent 75 percent of the total weight shipped.

b. Cost Sensitivities. Nominal costs are dominated by space, reflecting the storage orientation of the wholesale system. This emphasis on space manifested itself in the economic evaluation of storage and handling systems. Materials handling mechanization dependent upon labor savings was not economically justified except in a few isolated cases such as horizontal transport, case sorting, and movement to and from storage in Flow Path No. 11. Conversely, storage aids and other devices to effect savings in space were almost always attractive. High bins, conventional racks, stacking frames, and racks for bulk items were justified and utilized to a large degree in the nominal cost development.

Techniques to improve utilization of space, identified by dividing assets into storage lot sizes for analysis, were also used to develop the most economical systems.

Mechanization was difficult to justify for other reasons as well. The physical nature of the materiel in some flow paths, such as vehicles and large items, does not lend itself to sophisticated mechanized handling. In some instances, where materiel physical characteristics are conducive to automated handling, order characteristics precluded economic justification. Case picking of subsistence is an example of this si-

tuation. Cases are regular in shape and weight, annual turnover is 5.6, and, at the higher throughput levels, case picking machines were reasonable alternatives to consider. However, these machines are designed to handle orders of many items with a few cases of each item. DOD subsistence orders consist of few items with several (more than one-half a palletload) cases each. The primary advantages of the picking machine -- reduction of travel time to several locations and automated case picking from several locations at once -- were minimized and the machines not justified.

To further emphasize the dependence upon space costs in Flow Path No. 11, pallet handling and storage requirements in the one to ten pallet per NSN lot size range did justify using an automatic stacker/retriever system. However, this justification resulted essentially from space savings instead of labor savings as would normally be expected.

In those process functions such as receiving, in-checking, and packing, where throughput volumes are large and unrelated to storage, machines and mechnization, such as conveyor and sortation systems, were justified and utilized.

EXHIBIT A

PLANNING FACTORS AND ASSUMPTIONS

Schedule A-I

Planning Factors

Planning factors are those parameters, concepts, and other facts provided to DS/SD by DODMDS as guidance for the development of nominal depot cost curves.

1. Total system inventory (assets) will remain constant regardless of the number of stocking locations.

2. Turnover of a given commodity is the same at each location stocking that commodity.

3. Nominal costs assume a uniform mix of NSN's within a DODMDS product group at all locations stocking that product group.

4. Regional differences in labor rates and construction costs will be reflected in the development of nominal depot cost curves.

5. Nominal cost curves will include annualized costs for new equipment and space to satisfy all space and equipment requirements.

6. Indirect variable and fixed support costs based on historical depot costs will be added to the nominal cost curves by the DODMDS Study Group.

7. Alternate storage and handling concepts will be evaluated by using the simple payback technique whereby incremental investments are compared with incremental savings. A payback of five years or less is considered to be acceptable.

8. No cost for land will be included.

9. Capital investments will be annualized as follows:

   Buildings -- 25 years
   Rack-supported buildings -- 15 years
   Operating equipment -- 10 years
   Automatic data processing equipment -- 8 years

The straight-line method of annualization will be used.

10. Incremental energy and maintenance costs will be included in nominal depot cost curves only when the level of sophistication of economically justified systems is at an identifiably higher level than that for existing systems.

11. Costs for supplies such as packing materiels will be estimated as a percentage of labor hours based upon DODMDS study year costs provided by DODMDS as follows:

Depot operation	Additional cost for supplies (percentage of direct labor cost)
Receiving	2
Packing	26
Bulk issue	1
Bin issue	1
Shipping	4

12. Containerization and Consolidation Point (CCP) activity and workload will be excluded from nominal depot cost curves.

13. Ammunition, Nuclear, and Industrial Plant Equipment will be excluded from the data base used to develop nominal costs.

14. Service unique practices will not be reflected in nominal cost curves.

15. Costs of packaging and preservation and unit and set assembly operations will not be included in nominal cost curve development. The historical costs for these operations will be added to the nominal costs by the DODMDS Study Group. Cost of materiel flows to and from packaging and preservation, and unit and set assembly will be included in the nominal cost curves.

16. Nominal costs will not reflect resources for accommodating mobilization situations.

17. Nominal cost curves will be for Fiscal Year 1976.

18. Flow paths will be independent of one another. Nominal cost curves will not reflect potential economies of scale resulting from combining flow paths at a depot because the optimization model cannot accept these combinations.

19. Nominal flow path cost curves will reflect the most economical combination of space, equipment, and labor.

20. Nominal depot cost curves will be provided for optimization input by flow path. Three curves for each flow path will be provided, one representing each construction/labor cost geographical depot grouping.

21. Nominal cost curves will be in the form of total annual cost plotted against total annual throughput in hundredweight. Depot throughput is considered to be the outbound activity.

22. A matrix relating flow paths to DODMDS product groups will be provided.

23. Nominal depot cost curves will be provided in the form of throughput (X) and cost (Y) coordinates for each point in which a change of slope occurs. A graphical representation of each curve will also be provided.

24. Special handling and storage requirements, as provided by DODMDS, will be reflected in cost curves to the extent that they can be identified in the available data.

25. All small arms (DODMDS Commodity 101) will be in a separate flow path regardless of the storage mode.

26. A special requirement for Flow Path 4 (small arms) is to provide for an annual 100 percent physical inventory by serial number.

27. Aircraft engines (Flow Path 6) and small arms (Flow Path 4) require serial number control.

28. Intradepot activity, such as movements to and from COMIS functions, will represent an additional depot workload which is developed from internal flow data.

29. Nominal cost curves will be developed using an average daily workload. The number of working days per year is 251.

30. Nominal costs will be based on wholesale data and requirements only.

31. Nominal costs will be based on the activity data provided by DODMDS. No attempt will be made to rationalize any difference between inbound and outbound total volumes.

32. Nominal costs will be based on a one-shift operation, five days per week.

33. Pallet equivalents calculated for use in nominal cost curve development reflect average issue sizes for each NSN.

34. The lowest calculated level of activity for a single flow path will be the systemwide wholesale activity for that flow path divided by 40 depots.

35. The maximum level of activity (throughput) for each flow path will be the systemwide wholesale activity.

36. Forecast year throughput level will be the same as for the DODMDS study year.

37. Asset data of materiel identified in DODMDS data base as being inactive due to condition code will be added to active asset data for nominal cost curve development.

38. Dimensional data used to develop nominal costs will be unit of issue dimensions. Dimensions of those NSN's having no recorded dimensional data will be approximated by a statistical procedure based upon the known characteristics.

39. Internal depot flow data will be extracted from the DODMDS facilities data call response (32-day census). This depot-specific information will be converted to commodity-specific data using a statistical transposition procedure.

40. The volume capacity of a pallet is 55 $feet^3$.

41. DOD standard 40- by 48-inch pallets will be used for all flow paths except for subsistence flow path in which GPC (Grocery Pallet Council) standard 48- by 40-inch pallets will be used.

42. UMMIPS service standards will be used.
Issue Priority Group I -- one day's depot processing time.
Issue Priority Group II -- two days' depot processing time.
Issue Priority Group III -- eight days' depot processing time.

43. NSN's having assets but with no outbound activity during Fiscal Year 1975 will be considered inactive.

44. Storage costs for inactive items will be included in the nominal cost curves for each flow path.

45. Inactive storage system will provide for a unique picking location for each NSN.

46. Handling requirements within inactive storage will be based on a percentage of wholesale issues for each flow path as follows:

Flow path number	Percentage of issues
1	2
2	2
3	2
4	3
5	15
6	2
7	10
8	0
9	0
10	2
11	2

47. Inside storage will be provided for all NSN's except those in DODMDS Product Groups 151, 152, 191, and 221.

48. Asset data storage modes are mutually exclusive. The order of priority in placing items in storage modes will be: cold, hazardous, security, all other.

49. Items requiring special storage modes will be identified as follows:

Storage mode	Item characteristics in DODMDS data
Cold	Water commodity code indicating reefer cargo.
Hazardous	Type of cargo code indicating hazardous cargo.
Security	Pilferage/security code indicating security required but not pilferable items.

50. For nominal cost curve development, security storage is vault-type storage as defined in AFIT Report[a], pp 80-81.

51. Labor performance standards used will primarily be those published in or derived from DOD 5010.15.1-M, Defense Work Measurement Standard Time Data Program, Volumes I-X. Depot-engineered and/or other time standards for handling and storage of specific commodities will also be used as appropriate and available.

52. Nominal costs will reflect good labor scheduling and control practices.

53. Nominal cost curves will be developed using a single wage rate for all supply operations.

54. One-half hour will be deducted from eight-hour workday to account for paid coffee breaks.

55. Labor rates to be used will be based on historical Fiscal Year 1975 labor rates at existing locations, which include fringe benefits and first-line supervision. Fiscal Year 1975 rates will be projected to 1976 for use in cost development.

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[a] U.S. Air Force Institute of Technology, Wright-Patterson AFB, Ohio, "A General Warehouse Module Conceptual Design and Cost Analysis," Report GCE/MC/76S-1, September 1976.

56. For development of vehicle loading/unloading costs, the following labor allocation will be used:

Mode		Percent depot labor	Percent carrier labor
LTL)	Off-	67	33
TL)	post	80	20
All truck)	destination	75	25
Rail		100	0
Parcel Post		60	40
On-post destination		100	0

Schedule A-II

Planning Assumptions

Planning assumptions are those assumptions made by DS/SD to fill data or informational voids needed for the development of nominal depot cost curves.

1. Labor/first-line supervisor ratio will be 12:1.

2. A personal, fatigue, and delay (PFD) factor of 20 percent will be used for labor calculations.

3. On-post shipments will be based on historical data and assumed to be constant regardless of number of locations.

4. Depot computer systems can provide requisitions in any sequence, format, and timeframe needed for handling system conceptual design.

EXHIBIT B

EQUIPMENT COSTS

Basic materials handling and storage equipment costs used to develop nominal depot costs are listed in Exhibit B.

CONTENTS

BATTERIES, BATTERY CHARGERS

Item	Unit	$ cost	Date
Batteries			
12 volt, 510 A-H for walkie pallet truck	Each	800	9/76
24 volt, 510 A-H for narrow aisle trucks	Each	1,500	9/76
36 volt, 600 A-H for light to medium duty	Each	3,000	9/76
850 A-H for medium to heavy duty	Each	3,500	9/76
48 volt, 600 A-H for medium to heavy duty	Each	4,000	9/76
850 A-H for heavy duty	Each	4,500	9/76
Battery Chargers			
Solid State, Silicon Diode			
12 volt, single phase for 510 A-H battery	Each	500	9/76
24 volt, single phase for 510 A-H battery	Each	600	9/76
36 volt, three phase for 600 A-H battery	Each	900	9/76
for 850 A-H battery	Each	1,100	9/76
48 volt, three phase for 600 A-H battery	Each	1,100	9/76
for 850 A-H battery	Each	1,300	9/76

All prices are FOB point of manufacture.

Source: Exide Power Systems Division, ESB Inc., New York, N.Y.

BINS AND SHELVES

Item	Unit	$ cost	Date
Bins and Shelves - Open Backs and Sides - 6 shelves			
Per section, Class 0 or 1			
36 x 12 x 7'-3"	Section	55	5/76
36 x 18 x 7'-3"	Section	65	5/76
36 x 24 x 7'-3"	Section	76	5/76
48 x 12 x 7'-3"	Section	60	5/76
48 x 18 x 7'-3"	Section	80	5/76
48 x 24 x 7'-3"	Section	91	5/76
Extra uprights (end of row) 12", 18" or 24"	Set	15	5/76
Bins and Shelves - Open Backs, Closed Sides - 6 shelves per section			
Class 0 or 1			
36 x 12 x 7'-3"	Section	73	5/76
36 x 18 x 7'-3"	Section	80	5/76
36 x 24 x 7'-3"	Section	93	5/76
48 x 12 x 7'-3"	Section	88	5/76
48 x 18 x 7'-3"	Section	95	5/76
48 x 24 x 7'-3"	Section	108	5/76
Extra Shelves			
36 x 12"	Each	6.75	5/76
36 x 18"	Each	8.50	5/76
36 x 24"	Each	10.40	5/76
Extra Uprights (end of row) 12", 18" or 24"	Set	20	5/76
3" High Bin Fronts			
36"	Each	2	5/76
48"	Each	5	5/76
Base Covers, 36" or 48"	Each	2	5/76
Label Holders, 36" or 48"	Each	1	5/76
Backs, 36" x 7'-3"	Each	16	5/76
48" x 7'-3"	Each	20	5/76
Dividers, 12" x 6"	Each	1	5/76
24" x 18"	Each	4	5/76

All prices FOB point of manufacture.
Installation with union labor in the New York area will approximate $1.00 per shelf.

Source: Lyon Metal Products, Inc.
New York Sales Representative

BIN BOXES

Item	Unit	$ cost	Date
Corrugated Bin Boxes 4½" High			
12 x 2	100 KD	25	6/76
12 x 4	100 KD	27	6/76
12 x 6	100 KD	29	6/76
12 x 8	100 KD	30	6/76
12 x 12	100 KD	34	6/76
18 x 2	100 KD	31	6/76
18 x 4	100 KD	32	6/76
18 x 6	100 KD	33	6/76
18 x 8	100 KD	37	6/76
18 x 10	100 KD	39	6/76
18 x 12	100 KD	44	6/76
Corrugated Bin Boxes 8" High			
12 x 4	100 KD	46	6/76
12 x 6	100 KD	50	6/76
Plastic Bin Boxes, 4" High			
12 x 2 - 24/ctn.	Each	0.85	6/76
12 x 4 - 24/ctn.	Each	1.08	6/76
12 x 6 - 24/ctn.	Each	1.21	6/76
12 x 10 - 24/ctn.	Each	2.75	6/76
Steel Bin Boxes - 4½" High			
12 x 5½ lots of 12	Each	1.94	6/76
18 x 5½ lots of 12	Each	2.79	6/76
12 x 8½ lots of 12	Each	2.79	6/76
18 x 8½ lots of 12	Each	3.66	6/76
Dividers - 5½"	Each	0.24	6/76
8"	Each	0.40	6/76

Prices are FOB point of manufacture or distributor's warehouse.

Source: Global Equipment Co.
Hempstead, N.Y.

GRAVITY CONVEYORS

Item	Unit	$ cost	Date
Gravity Wheel Conveyor			
18" Steel Wheel - 16 whls/ft.	10 ft.	87.50	5/76
18" Alum. Wheel - 16 whls/ft.	10 ft.	98.00	5/76
24" Steel Wheel - 18 whls/ft.	10 ft.	104.00	5/76
24" Alum. Wheel - 18 whls/ft.	10 ft.	120.00	5/76
30" Steel Wheel - 24 whls/ft.	10 ft.	123.40	5/76
30" Alum. Wheel - 24 whls/ft.	10 ft.	137.90	5/76
Gravity Roller Conveyor			
Light Duty - 1-3/8" rollers			
12" Steel - 1½" roller spacing	10 ft.	122.45	6/76
12" Alum. - 1½" roller spacing	10 ft.	166.65	6/76
12" Steel - 3" roller spacing	10 ft.	69.20	6/76
12" Alum. - 3" roller spacing	10 ft.	99.95	6/76
12" Steel - 4½" roller spacing	10 ft.	51.75	6/76
12" Alum. - 4½" roller spacing	10 ft.	78.35	6/76
12" Steel - 6" roller spacing	10 ft.	42.65	6/76
12" Alum. - 6" roller spacing	10 ft.	66.50	6/76
18" Steel - 1½" roller spacing	10 ft.	145.35	6/76
18" Alum. - 1½" roller spacing	10 ft.	209.50	6/76
18" Steel - 3" roller spacing	10 ft.	81.05	6/76
18" Alum. - 3" roller spacing	10 ft.	124.95	6/76
18" Steel - 4½" roller spacing	10 ft.	60.50	6/76
18" Alum. - 4½" roller spacing	10 ft.	96.95	6/76
18" Steel - 6" roller spacing	10 ft.	49.10	6/76
18" Alum. - 6" roller spacing	10 ft.	82.40	6/76
24" Steel - 1½" roller spacing	10 ft.	170.30	6/76
24" Alum. - 1½" roller spacing	10 ft.	259.40	6/76
24" Steel - 3" roller spacing	10 ft.	96.10	6/76
24" Alum. - 3" roller spacing	10 ft.	154.40	6/76
24" Steel - 4½" roller spacing	10 ft.	72.20	6/76
24" Alum. - 4½" roller spacing	10 ft.	120.80	6/76
24" Steel - 6" roller spacing	10 ft.	58.80	6/76
24" Alum. - 6" roller spacing	10 ft.	103.45	6/76
90° Curves - 24" Inside Radius			
12" Steel	Each	77.35	6/76
12" Aluminum	Each	106.15	6/76
18" Steel	Each	89.05	6/76
18" Aluminum	Each	122.35	6/76
24" Steel	Each	183.50	6/76
24" Aluminum	Each	231.75	6/76
45° Curves - 24" Inside Radius			
12" Steel	Each	59.30	6/76
12" Aluminum	Each	74.45	6/76
18" Steel	Each	61.65	6/76
18" Aluminum	Each	84.05	6/76
24" Steel	Each	110.25	6/76
24" Aluminum	Each	147.75	6/76

GRAVITY CONVEYORS

Item	Unit	$ cost	Date
Gravity Roller Conveyor (cont'd.)			
Tripod Supports for Wheel and 1-3/8" roller conveyor			
12"-24" widths, 18"-25" height	Each	13.80	6/76
12"-24" widths, 24"-40" height	Each	14.50	6/76
12"-24" widths, 35"-52" height	Each	15.40	6/76
12"-24" widths, 41"-66" height	Each	18.15	6/76
Side Guard Rails - Both sides	10 ft.	25.80	6/76
Medium Duty - 1.9" Steel rollers			
12"-3" roller spacing	10 ft.	106.55	6/76
-4½" roller spacing	10 ft.	81.75	6/76
-6" roller spacing	10 ft.	68.00	6/76
-9" roller spacing	10 ft.	56.60	6/76
18"-3" roller spacing	10 ft.	119.45	6/76
-4½" roller spacing	10 ft.	90.15	6/76
-6" roller spacing	10 ft.	74.45	6/76
-9" roller spacing	10 ft.	61.20	6/76
24"-3" roller spacing	10 ft.	131.80	6/76
-4½" roller spacing	10 ft.	98.50	6/76
-6" roller spacing	10 ft.	80.55	6/76
-9" roller spacing	10 ft.	65.85	6/76
36"-3" roller spacing	10 ft.	154.40	6/76
-4½" roller spacing	10 ft.	115.65	6/76
-6" roller spacing	10 ft.	93.35	6/76
-9" roller spacing	10 ft.	74.45	6/76
90° Curves			
12" - 32½" inside radius	Each	99.15	6/76
18" - 32½" inside radius	Each	112.40	6/76
24" - 32½" inside radius	Each	168.80	6/76
36" - 48" inside radius	Each	224.20	6/76
Support Stands for 1.9" roller conveyor			
All widths 17"-20" high	Each	15.20	6/76
20"-26" high	Each	17.55	6/76
24"-30" high	Each	18.70	6/76
28"-40" high	Each	20.60	6/76
38"-50" high	Each	23.25	6/76
50"-62" high	Each	26.65	6/76
Heavy Duty - 2.5" Steel Rollers			
18"-3" roller spacing	10 ft.	311.50	6/76
-4" roller spacing	10 ft.	248.80	6/76
-6" roller spacing	10 ft.	187.20	6/76
-8" roller spacing	10 ft.	155.10	6/76
-12" roller spacing	10 ft.	124.20	6/76
24"-3" roller spacing	10 ft.	350.30	6/76
-4" roller spacing	10 ft.	277.90	6/76
-6" roller spacing	10 ft.	205.80	6/76
-8" roller spacing	10 ft.	170.40	6/76
-12" roller spacing	10 ft.	133.60	6/76

Item	Unit	$ cost	Date
Gravity Roller Conveyor (cont'd.)			
Heavy Duty - 2.5" Steel Rollers (cont'd.)			
30"-3" roller spacing	10 ft.	391.60	6/76
-4" roller spacing	10 ft.	308.60	6/76
-6" roller spacing	10 ft.	227.30	6/76
-8" roller spacing	10 ft.	185.80	6/76
-12" roller spacing	10 ft.	144.40	6/76
36"-3" roller spacing	10 ft.	431.50	6/76
-4" roller spacing	10 ft.	339.40	6/76
-6" roller spacing	10 ft.	247.20	6/76
-8" roller spacing	10 ft.	201.20	6/76
-12" roller spacing	10 ft.	153.40	6/76
90° Curves			
18" - 32½" inside radius	Each	186.20	6/76
24" - 32½" inside radius	Each	212.90	6/76
30" - 48" inside radius	Each	439.10	6/76
36" - 48" inside radius	Each	479.10	6/76
Support Stands for 2.5" roller conveyor			
All widths 18"-21"	Each	20.65	6/76
21"-24"	Each	21.70	6/76
24"-30"	Each	26.05	6/76
30"-36"	Each	28.25	6/76
36"-48"	Each	32.80	6/76
48"-60"	Each	36.60	6/76
Telescoping Gravity Conveyor			
1.9" rollers on 3" centers			
12" - 11' to 20'	Assembly	519.30	6/76
12' to 30'	Assembly	737.10	6/76
13' to 40'	Assembly	955.00	6/76
18" - 11' to 20'	Assembly	545.30	6/76
12' to 30'	Assembly	776.10	6/76
13' to 40'	Assembly	1,006.80	6/76
Installation - Gravity Conveyors			
Floor supported	Lin. ft.	2. to 2.50	5/76
Ceiling Supported	Lin. ft.	4. to 5.00	5/76

POWERED CONVEYORS

Item	Unit	$ cost	Date
Powered Belt Conveyors			
Belt on roller, 12" roller spacing or slider bed, end drive, w/o motor			
24" - 50 ft. length	Lin. ft.	30.50	5/76
- 100 ft. length	Lin. ft.	26.46	5/76
30" - 50 ft. length	Lin. ft.	36.00	5/76
- 100 ft. length	Lin. ft.	31.43	5/76
36" - 50 ft. length	Lin. ft.	40.80	5/76
- 100 ft. length, roller bed only	Lin. ft.	35.81	5/76
- 100 ft. length, slider bed	Lin. ft.	39.11	5/76
Belt on roller, 12" roller spacing or slider bed, center drive, w/o motor			
24" - 50 ft. long	Lin. ft.	44.74	5/76
- 100 ft. long	Lin. ft.	34.92	5/76
30" - 50 ft. long	Lin. ft.	54.44	5/76
- 100 ft. long	Lin. ft.	40.73	5/76
36" - 50 ft. long	Lin. ft.	60.92	5/76
- 100 ft. long, roller bed only	Lin. ft.	45.87	5/76
- 100 ft. long, slider bed	Lin. ft.	49.17	5/76
Live Roller Conveyors			
Belt driven live roller, 4" load roller spacing, w/o motor			
24" - 50 ft. long	Lin. ft.	37.50	5/76
- 100 ft. long	Lin. ft.	39.47	5/76
30" - 50 ft. long	Lin. ft.	40.30	5/76
- 100 ft. long	Lin. ft.	42.02	5/76
36" - 50 ft. long	Lin. ft.	42.60	5/76
- 100 ft. long	Lin. ft.	44.07	5/76
Support Stands (for belt and live roller conveyor - 36" Hi ± 3")			
24" conveyor	Each	19.30	5/76
30" conveyor	Each	19.70	5/76
36" conveyor	Each	20.15	5/76
Motors (single speed, 3 Ø)			
1½ HP	Each	400.00	5/76
3 HP	Each	639.00	5/76

POWERED CONVEYORS

Item	Unit	$ cost	Date
Installation - Powered Conveyors			
Mechanical	50% of material cost		5/76
Electrical - depends on complexity and length of wire runs.			
(Allow at least $500 per motor and $300 for each control device plus material cost)			5/76
Cantilever Extendible Powered Conveyor			
2 Boom - 26'-4" to 63'-4"	Assembly	29,000	5/76
3 Boom - 18'-6" to 55'-6"	Assembly	32,000	5/76
For power traverse add		3,000	5/76
Mechanical Installation		1,200	5/76

Material prices FOB point of manufacture.

Sources: (All conveyors)

All-States Pallet & Equipment Co.
Jersey City, N.J.

Global Equipment Co.
Hempstead, N.Y.

Rapistan, Inc., Piscataway, N.J.

PACKAGE SORTING CONVEYORS

Item	Unit	$ cost	Date
Sortrac IA (pneumatic pushoff)			
Diverter	Station	720	7/76
Memory	System	8,000	7/76
Plus	Station	125	7/76
Sortrac IB (rotary)			
Diverter	Station	1,500	7/76
Sortrac IC (overhead pusher)			
Diverter	Station	4,000	7/76
Sortrac III (Tilt Slat)			
200 pcs./min.	Lin.ft.	900	7/76
Minimum	System	300,000	7/76
Tilt Tray - 100 sorts			
60 pcs./min. - Mechanical	System	250,000	7/76
Memory	System	50,000	7/76
Auto-Induction	Station	25,000	7/76

All prices hardware only FOB factory.

Sources: Integrated Handling Systems Div., ACCO, Chicago
Logan Div., ATO, Louisville, KY.

CRANES AND HOISTS

Item	Unit	$ cost	Date
Wall Mounted Jib Cranes, Top Braced			
Capy 1,000#, 8' Boom	Each	334	6/76
16' Boom	Each	436	6/76
2,000#, 8' Boom	Each	346	6/76
16' Boom	Each	552	6/76
4,000#, 8' Boom	Each	545	6/76
16' Boom	Each	690	6/76
6,000#, 8' Boom	Each	593	6/76
16' Boom	Each	787	6/76
Wall Mounted Jib Crane, Underbraced			
Capy 1,000#, 8' Boom	Each	552	6/76
16' Boom	Each	757	6/76
2,000#, 8' Boom	Each	605	6/76
16' Boom	Each	890	6/76
4,000#, 8' Boom	Each	787	6/76
16' Boom	Each	1,283	6/76
6,000#, 8' Boom	Each	890	6/76
16' Boom	Each	1,392	6/76
Pedestal Jib, 360° Rotation, 12' Clear			
Capy 1,000#, 8' Boom	Each	822	6/76
16' Boom	Each	1,283	6/76
2,000#, 8' Boom	Each	1,007	6/76
16' Boom	Each	1,725	6/76
4,000#, 8' Boom	Each	1,368	6/76
16' Boom	Each	1,771	6/76
6,000#, 8' Boom	Each	1,460	6/76
16' Boom	Each	2,246	6/76
Electrification Kit for Pedestal Jib	Set	291	6/76
Trolleys for Jib Cranes			
Capy 1,000#	Each	45.50	6/76
2,000#	Each	62.25	6/76
4,000#	Each	109.00	6/76
6,000#	Each	129.00	6/76
Chain Hoists, 10' Lift, Spur Gear			
Capy 1,000#	Each	71.25	6/76
2,000#	Each	95.00	6/76
4,000#	Each	144.00	6/76
6,000#	Each	206.00	6/76

CRANES AND HOISTS

Item	Unit	$ cost	Date
Electric Hoists, 10' Lift, Pend Control			
Capy 1,100#, speed 13½ fpm, headroom 19"	Each	468.95	6/76
2,200#, speed 16.7 fpm, headroom 20½"	Each	485.00	6/76
2,000#, speed 29.7 fpm, headroom 21"	Each	624.00	6/76
4,400#, speed 8.4 fpm, headroom 26½"	Each	612.00	6/76
4,000#, speed 27.1 fpm, headroom 24"	Each	825.00	6/76
6,600#, speed 5.6 fpm, headroom 32"	Each	888.00	6/76
6,000#, speed 16.1 fpm, headroom 34"	Each	1,095.00	6/76
Adjustable Portable Gantry Cranes			
Height Range 8'-12', Span 15'			
Capy 1,000#	Each	1,706	6/76
2,000#	Each	1,333	6/76
4,000#	Each	1,422	6/76
6,000#	Each	1,735	6/76
Overhead Bridge Crane, Double Girder, 10,000# Capy.			
123' Span, installed	Each	15,000-18,000	5/67
Powered, Truck Mounted, 20,000# Capy			
40' Boom	Each	21,000-25,000	5/67
Mini-Stacker Crane System			
40' High, 75-85 ft. long			
500#/container w/computer control			
installed, less racks	Each	35,000	5/76
Racks, approx. 1,000 openings	Opening	50	5/76
Stacker Crane, 40' High			
Manual Control, No Racks	Each	60,000	5/76
Transfer Car for above	Each	40,000	5/76
Stacker Crane, Automatic			
75' High, No Racks		100,000-150,000	7/76

Sources: Global Equipment Co.
Hempstead, NY

B.E. Wallace Products Corp.
Exton, PA

Supreme Equipment & Systems Corp.
Brooklyn, NY

Clark Equipment Co.
Battle Creek, Mich.

J.B. Webb Co.
Detroit, Mich.

DOCK ACCESSORIES

Unit	Unit	$ cost	Date
Dock Levelers			
Mechanical 7x8	Each	1,430	5/76
Panic Stops (Kelley)	Pair	250	5/76
Installation, No Concrete work	Each	150	5/76
Hydraulic 7x8	Each	1,665	5/76
Installation, No Concrete Work, no field wiring	Each	150	5/76
Approx. Freight, Mech. or Hydraulic			
East Coast	Each	150	5/76
West Coast	Each	250	5/76
For 3 Ø Motor add	Each	115	5/75
Truck Levelers, Hinged			
Hydraulic, 9x16, 36" Travel	Each	4,000	5/76
Mechanical Installation	Each	500	5/76
Approx. Freight			
East Coast	Each	350	5/76
West Coast	Each	700	5/76
Dock Boards, Portable			
Steel 48" W x 36" L, 6,000# Capy	Each	185	6/76
Steel 60" W x 72" L, 6,000# Capy	Each	368	6/76
Steel 48" W x 36" L, 10,000# Capy	Each	245	6/76
Steel 60" W x 72" L, 10,000# Capy	Each	543	6/76
Aluminum, 54" W x 36" L, 5,000# Capy	Each	232	6/76
Aluminum, 72" W x 72" L, 5,000# Capy	Each	594	6/76
Aluminum, 60" W x 36" L, 10,000# Capy	Each	291	6/76
Aluminum, 78" W x 72" L, 10,000# Capy	Each	764	6/76
Wheel Chock, Urethane, 1-5 pairs	Pair	31	6/76
Wheel Chock, Urethane, 6+ pairs	Pair	29	6/76
Pallet Grabber	Each	59	6/76
Wheel Riser, 18" W x 50" L x 6" H	Each	147	6/76
Wheel Riser, 24" W x 74" L x 12" H	Each	281	6/76
Bumpers, Laminated, 14x10x4	Each	17	6/76
Bumpers, Laminated, 38x12x4½	Each	35	6/76
Door Seals			
Economy Type, Sponge Rubber	Set	147	5/76
Good Quality, With Covers	Set	750	5/76
Best Quality, Sliding Head Piece	Set	850-1,000	5/76
Rubber Doors, w/vision panel			
6 x 4	Pair	570	6/76
7 x 6	Pair	714	6/76
8 x 8	Pair	922	6/76
9 x 9	Pair	1,064	6/76
10 x 10	Pair	1,169	6/76
Loading light w/bracket & guard, 3 or more	Each	77	6/76

DOCK ACCESSORIES

Sources: The Jennings Company (Kelly, Autoquip, Frommelt)
Long Island City, NY

Global Equipment Co.
Hempstead, NY

ELEVATORS AND PLATFORM LIFTS

Item	Unit	$ cost	Date
Hydraulic Platform Lifts (Electric)			
Capacity 500#, 12 x 25 deck, 4-7/8-30½ hgt.	Each	930	6/76
1,000#, 16 x 34 deck, 6½-36½ hgt.	Each	980	6/76
3,000#, 72 x 96 deck, 4½-60 hgt.	Each	2,586	6/76
3,000#, 84 x 120 deck, 5-60½ hgt.	Each	3,002	6/76
5,000#, 72 x 96 deck, 5-60½ hgt.	Each	2,939	6/76
5,000#, 84 x 120 deck, 5-60½ hgt.	Each	3,355	6/76
Hydraulic Freight Elevators			
Capacity 20,000#, 50' Rise, lift trucks	Each	60,000-65,000	9/76
Capacity 20,000#, 50' Rise, no lift trucks	Each	45,000-50,000	9/76
Electric Freight Elevators			
Capacity 20,000#, 50' Rise, lift trucks	Each	80,000-85,000	9/76
Capacity 20,000#, 50' Rise, no lift trucks	Each	50,000-55,000	9/76

Elevator prices include automatic controls, powered bi-parting doors and installation, not applicable to New York area.

Sources: Global Equipment Co., Hempstead, NY
H.J. Pasternak, Elevator Consultant, New York, NY

FORK LIFT TRUCKS

Class I -- Battery Operated, Center Control, Sit-Down, Counterbalanced

Item	Unit	$ cost	Date
Light Duty, 2,000# @ 24" LC, 189" Lift	Each	12,000	5/76
Battery and Charger	Set	2,000	5/76
Standard Duty, 2,000# @ 24" LC, 130" Lift	Each	12,000-12,500	10/76
Standard Duty, 2,000# @ 24" LC, 189"-192" Lift	Each	12,500-13,500	10/76
Battery and Charger	Set	2,700	5/76
Standard Duty, 3,000# @ 24" LC, 130" Lift	Each	15,500-16,500	10/76
Standard Duty, 3,000# @ 24" LC, 187"-192" Lift	Each	16,000-17,500	10/76
Battery and Charger	Set	4,000	5/76
Standard Duty, 4,000# @ 24" LC, 130" Lift	Each	16,000-17,000	10/76
Standard Duty, 4,000# @ 24" LC, 187"-192" Lift	Each	16,500-18,000	10/76
Battery and Charger	Set	4,400	5/76
Standard Duty, 6,000# @ 24" LC, 122"-130" Lift	Each	17,000-21,000	10/76
Standard Duty, 6,000# @ 24" LC, 170"-192" Lift	Each	18,000-21,650	10/76
Battery and Charger	Set	5,000	5/76

FORK LIFT TRUCKS

Class II — Battery Operated, Driver Ride, Narrow Aisle Trucks

Item	Unit	$ cost	Date
2,000# @ 24" LC, 130 Lift, Straddle	Each	9,000-9,500	10/76
2,000# @ 24" LC, 180"-201" Lift Straddle	Each	9,200-11,700	10/76
Battery and Charger	Set	2,400	5/76
4,000# @ 24" LC, 128"-142" Lift, Straddle	Each	9,100-11,000	10/76
4,000# @ 24" LC, 180"-207" LIft, Straddle	Each	10,800-12,700	10/76
Battery and Charger	Set	2,600	5/76
2,000# @ 24" LC, 126"-133" Lift, Reach	Each	10,800-12,400	10/76
2,000# @ 24" LC, 180"-205" Lift, Reach	Each	12,300-13,500	10/76
Battery and Charger (24V)	Set	2,400	5/76
4,000# @ 24" LC, 118"-133" Lift, Reach	Each	12,800-14,500	10/76
4,000# @ 24" LC, 175"-196" Lift, Reach	Each	14,300-15,700	10/76
Battery and Charger (24V)	Set	2,600	5/76
4,000# @ 24" LC, 118"-133" Lift, Reach	Each	13,600-16,000	10/76
4,000# @ 24" LC, 175"-196" Lift, Reach	Each	15,500-17,300	10/76
Battery and Charger (36V)	Set	3,500	9/76
3,000# @ 24" LC, 144"-192" Lift, Order Picker	Each	9,300-12,700	10/76
3,000# @ 24" LC, 180"-240" Lift, Order Picker	Each	10,000-14,400	10/76
4,000# @ 24" LC, 264" Lift, Order Picker	Each	17,000	5/76
Battery and Charger	Set	2,700	5/76
4,000# @ 24" LC, 360" Lift, Side Loader Including Battery and Charger	Each	45,000	5/76
6,000# @ 24" LC, 240" Lift, Side Loader Including Battery and Charger	Each	39,000	5/76
4,000# @ 24" LC, 240" Lift, 4D Including Battery and Charger	Each	23,700	5/76
4,000# @ 24" LC, 360" Lift, Swing Reach Including Battery and Charger	Each	52,000	5/76
4,000# @ 24" LC, 480" Lift, Swing Reach Including Battery and Charger	Each	67,000	5/76

FORK LIFT TRUCKS

Class III -- Battery Operated, Driver Lead Trucks

Item	Unit	$ cost	Date
Low-Lift Pallet Truck, 4,000# capacity	Each	3,300-3,600	10/76
Low-Lift Pallet Truck, 6,000# capacity	Each	3,400-3,800	10/76
Battery and Charger	Set	1,000	5/76
Low-Lift Pallet Truck, Walk or Ride, 4,000#	Each	3,600-4,300	10/76
Straddle Stacker, 2,000# capacity, 130" Lift	Each	5,600-6,500	10/76
Straddle Stacker, 4,000# capacity, 130" Lift	Each	6,000-7,500	10/76
Straddle Stacker, 2,000# capacity, 107" Lift Including Battery and Charger	Each	6,040[a]	8/76
Reach Truck, 2,000# capacity, 130" Lift	Each	7,400-9,400	10/76
Reach Truck, 4,000# capacity, 130" Lift	Each	8,400-9,600	10/76
Counter Balanced, 2,000# capacity, 130" Lift	Each	4,400-6,900	10/76
Counterbalanced Stacker, 4,000# capacity, 130" Lift	Each	7,200-9,100	10/76
Battery and Charger for all Walkie Stackers	Set	1,300	10/76

[a]Bid price: Yale VF-020-5071 w/510 AH battery.

FORK LIFT TRUCKS

Class IV -- Gasoline, Diesel or LPG Fueled, Solid Tired Lift Trucks of all Types.

	Unit	$ cost	Date
2,000# @ 24" LC, 231" Lift	Each	11,340	5/76
4,000# @ 24" LC, 244" Lift	Each	15,020	5/76
6,000# @ 24" LC, 240" Lift	Each	18,133	5/76

Note: All trucks with lifts in excess of 156" are derated at 5% per foot in excess of 156 inches.

Sources: 5/76 Prices: Clark Equipment Co., New York Office
Jules Dierck Equipment Co., Long Island City, NY
Otis Material Handling, New York Office
10/76 Prices: Otis Material Handling, Cleveland, Ohio

LIFT TRUCK ACCESSORIES

Item	Unit	$ cost	Date
Clamps			
Clamps w/o Arms or Backrest			
2,000# @ 24" LC 16"-60" range	Each	1,120	6/76
Same with side shift	Each	1,345	6/76
4,000# @ 24" LC 18½"-71" range	Each	1,740	6/76
Same with side shift	Each	1,965	6/76
6,500# @ 24" LC 21"-85" range	Each	2,500	6/76
Same with side shift	Each	2,725	6/76
2,000# Revolving	Each	3,810	6/76
2,000# Revolving	Each	4,915	6/76
6,500# Revolving	Each	6,340	6/76
Clamp Arms to Bolt On			
Bale, 2,000#	Pair	265	6/76
4,000#	Pair	590	6/76
6,500#	Pair	820	6/76
Drum, 2,000#	Pair	355	6/76
4,000#	Pair	655	6/76
Multi-Purpose, 2,000#	Pair	530	6/76
4,000#	Pair	605	6/76
6,500#	Pair	830	6/76
Bolt on Forks, 48", 2,000#	Pair	385	6/76
4,000#	Pair	530	6/76
6,500#	Pair	640	6/76
Back Rest 48x36	Each	380	6/76
48x48	Each	565	6/76
Carton Clamp, 2,000# @ 24" LC side shift, back rest 48" arms	Each	4,535	6/76
Paper Roll Clamp, 4,000# @ 50" LC 360° Rotation 10"-50" range	Each	5,815	6/76
Pushers, w/platens, 4,000# @ 24" LC	Each	4,105	6/76
same w/side shift	Each	4,600	6/76
Push/pull, w/platens, 4,000# @ 24" LC	Each	5,090	6/76
same w/side shift	Each	5,585	6/76
Load Rotator, 4,000# @ 24" LC	Each	6,675	6/76
Rotator w/fork bars only			
4,000# @ 24" LC	Each	2,530	6/76
5,000# @ 24" LC	Each	2,965	6/76
Rotator w/48" forks			
4,000# @ 24" LC	Each	2,955	6/76
5,000# @ 24" LC	Each	3,400	6/76
Side Shifter w/back rest			
3,000# @ 24" LC	Each	510	6/76
5,000# @ 24" LC	Each	655	6/76

LIFT TRUCK ACCESSORIES

Item	Unit	$ cost	Date
Hose Reels	Each	130-145	6/76
Cable Reels	Each	270	6/76
Hose/cable Reels	Each	225-240	6/76
Crane Attachment, 3,000# capacity	Each	395	6/76

Prices shown are FOB factory no discounts considered.

Source: Cascade Corp.
Portland, Ore.

Global Equipment Co.
Hempstead, NY

HAND TRUCKS

Item	Unit	$ cost	Date
Two Wheel Hand Trucks			
500# Utility, tubular frame	Each	32	6/76
400# Aluminum	Each	55-65	6/76
Appliance Truck w/straps and Climbers	Each	96	6/76
1,400# Heavy Duty	Each	152	6/76
Four-wheel Stock Carts	Each	50-150	6/76
Four-wheel Order Picking Carts	Each	90-115	6/76
Four-wheel Platform Trucks	Each	115-400	6/76
Four-wheel Canvas Hampers	Each	50-100	6/76
Semi-Live Skids, 2,000# Capy	Each	84-105	6/76
Semi-Live Skids Handle	Each	62	6/76
Pallet Jack, 48" Forks, 27" Wide			
3,000# Capy	Each	350	6/76
5,000# Capy	Each	385	6/76
6,500# Capy	Each	540	6/76
4,000# Capy Blue Giant	Each	307[a]	8/76

Prices FOB factory -- no quantity discounts considered.

Source: Global Equipment Co.
Hempstead, NY

[a]Bid Price, Delivered, Elmira, NY

MISCELLANEOUS EQUIPMENT

Item	Unit	$ cost	Date
Shrink Wrap Tunnel, to			
Handle pallets 48x48x48x2,500#			
120 pallets/hr			
Automatic Bag Loader	Each	60,000	5/76
Tunnel	Each	25,000	5/76
Conveyor & Controls	Each	15,000	5/76
Installation-Mechanical	System	1,200	5/76
Installation-Electrical	System	1,200	5/76
Stretch Wrap Equipment			
Economy Model	Each	22,000	5/76
High Speed Model	Each	60,000	5/76
Automatic Strapping Machines			
Up to 20 straps/minute	Each	6,000	6/76
2 Ø to 60 straps/minute	Each	15,000	6/76
Tape Dispenser, Electric			
Lever Control, 1½"-3"W	Each	130	6/76
Dial control, 1½"-3"W	Each	180	6/76
Postal Scale			
Capy, 70#, rate charts & Zone keys	Each	650	6/76
Bench Scale			
14x17 platform, vertical dial			
60# x 1 oz., 100# x 1/10#, 125# x 2 oz.			
250# x 40 oz.	Each	583	6/76
Platform Scale			
Beam Type			
14x17 pfm, capy 300#, beam 15#x1 oz.	Each	280	6/76
19x28 pfm, capy 1,000#, beam 100#x½#	Each	332	6/76
28x28 pfm, capy 2,000#, beam100#x½#	Each	621	6/76
Safety Ladders			
6 step, 87" H, 9'-9" Work hgt.	Each	325	6/76
8 step, 106" H, 10'-10" Work hgt.	Each	363	6/76
10 step, 125" H, 12'-5" Work hgt.	Each	402	6/76
11 step, 134½" H, 13'-2½" Work hgt.	Each	422	6/76
Portable Baler, Horizontal			
Bale Size, 42x30x20			
Hopper Size, 40x30x20			
Machine L-15', W-3', H-3'	Each	4,595	6/76
Est. freight to East Coast	Each	200	6/76

Except as otherwise indicated, prices are FOB factory.

Sources: Weldotron Industrial Packaging Systems, Piscataway, NJ
The Signode Company, Carlstadt, NJ
Global Equipment Co., Hempstead, NY
The Jennings Company (Maren), Long Island City, NY

PALLETS

Item	Unit	$ Cost	Date
Hardwood Pallets, GMA Standard Non-Reversible, 4 way, chamfered bottom edge boards Top deck: 2-1x6 5-1x4 Bottom deck: 2-1x6 3-1x4 Spacing Approx. 3 in. In truckload lots delivered in New York Area			
48x40 (432-480/T/L)	Each	4.50-5.50	5/76
48x[illegible] (360-380/T/L)	Each	5.50-6.50	5/76
Reduce Board Spacing to 1½"-Add	Each	1.00	5/76
Eliminate 4 way entry-Deduct	Each	0.15	5/76
Make Reversible-Add	Each	0.75	5/76
Bid Price 48x40 - 1½" spacing, 1 T/L NWPMA "Premium" grade Deld Elmira		6.29	8/76
Slave Pallets, Metal Clad Wood for storage and retrieval systems	Each	40-80	7/76

Sources: Axiom Products Co.
Carlstadt, N.J.

The Logan Co., Div. ATO
Louisville, KY

RACKS, PALLET

Item	Unit	$ cost	Date
Selective Racks – General Installed	pallet position	18-24	7/76
Selective Pallet Racks 22' high (5 levels), 9' load	pallet position	19.50	6/76
beams, 44" deep, 3000#/pallet Installation, union	pallet position	3.75	6/76
Drive-in Racks – General Installed	pallet position	23-37	7/76
Drive-thru Racks – General Installed	pallet position	25-30	7/76
Swing Reach Pallet Racks 40' high (8 levels) 2 deep	pallet position	26.30	6/76
incl. guide rail Installation, union	pallet position	6.30	6/76
Man Ride Stacker Racks 63' high (13 levels, including Lower rail)	pallet position	45.90	6/76
Installation	pallet position	12.50	6/76
Automatic Stacker Racks 63' high (13 levels, including Lower rail)	pallet position	72.05	6/76
Installation	pallet position	26.00	6/76
3/4" plywood decking	sq.ft.	0.50	6/76

Prices are FOB point of manufacture.

Sources: Speed Rack, Inc., Natick, Mass.
W+H Conveyor Systems, Carlstadt, N.J.
Interlake, Inc., Chicago, Ill.

RACKS, STEEL STORAGE

Item	Unit	$ cost	Date
Single Sided Uprights			
8' High, 12,000# capacity			
for 12" & 18" arms	Each	97.65	6/76
for 24" arms	Each	100.70	6/76
for 30" & 36" arms	Each	108.30	6/76
for 42" & 48" arms	Each	114.60	6/76
10' High, 16,000# capacity			
for 12" & 18" arms	Each	123.20	6/76
for 24" arms	Each	126.05	6/76
for 30" & 36" arms	Each	129.25	6/76
for 42" & 48" arms	Each	140.40	6/76
12' High, 18,000# capacity			
for 12" & 18" arms	Each	152.95	6/76
for 24" arms	Each	155.80	6/76
for 30" & 36" arms	Each	163.90	6/76
for 42" & 48" arms	Each	170.15	6/76
Double Sided Uprights			
8' High, 24,000# capacity			
for 12" x 18" arms	Each	113.60	6/76
for 24" arms	Each	120.00	6/76
for 30" & 36" arms	Each	131.85	6/76
for 42" & 48" arms	Each	146.70	6/76
10' High, 32,000# capacity			
for 12" & 18" arms	Each	139.40	6/76
for 24" arms	Each	145.80	6/76
for 30" & 36" arms	Each	157.70	6/76
for 42" & 48" arms	Each	171.60	6/76
12' High, 36,000# capacity			
for 12" & 18" arms	Each	169.15	6/76
for 24" arms	Each	175.25	6/76
for 30" & 36" arms	Each	185.60	6/76
for 42" & 48" arms	Each	201.30	6/76
Horizontal Brace Sets (2/set)			
8' High, 3' long	Set	21.25	6/76
8' High, 6' long	Set	34.75	6/76
10', 12' High, 3' long	Set	31.75	6/76
10', 12' High, 6' long	Set	51.10	6/76

RACKS, STEEL STORAGE

Item	Unit	$ cost	Date
Straight Arms, with or without Lip			
12" Long, 3,000# capacity	Each	9.25	6/76
18" Long, 2,900# capacity	Each	10.10	6/76
24" Long, 2,000# capacity	Each	10.85	6/76
30" Long, 1,600# capacity	Each	12.80	6/76
36" Long, 1,300# capacity	Each	13.40	6/76
42" Long, 1,145# capacity	Each	14.55	6/76
48" Long, 1,000# capacity	Each	15.45	6/76
Inclined Arms			
12" Long, 3,000# capacity, 5" incline	Each	9.70	6/76
18" Long, 2,500# capacity, 7" incline	Each	10.50	6/76
24" Long, 2,000# capacity, 9" incline	Each	11.30	6/76

Installation

Installation cost approximates 25% of material cost.

Prices shown are FOB point of manufacture.

Source: Global Equipment Co.
Hempstead, N.Y.

TOWLINES

Item	Unit	$ cost	Date
Light Duty Towline - Side-finger chain			
Straight Track	Lin. ft.	23	5/76
90° Turn (24" Rad)	Each	275	5/76
Drive up to 5HP w/controls	Each	7,000	5/76
Accumulation Stops	Each	1,050	5/76
Chain crossover	Each	3,050	5/76
Standard Duty Towline-Shallow Trench			
Straight Track	Lin. ft.	23	5/76
180° Turn (36" Rad)	Each	1,180	5/76
90° Turn (36" Rad)	Each	725	5/76
45° Turn (36" Rad)	Each	515	5/76
30° Turn (36" Rad)	Each	460	5/76
15° Turn (36" Rad)	Each	420	5/76
10 HP Drive w/control elements			
For 3560 chain (65,000#)	Each	17,250	5/76
For 3540 chain (48,000#)	Each	14,600	5/76
Drive Enclosure	Each	1,650	5/76
Non-powered spur up to 35 ft.	Each	1,400	5/76
Added Spur length	Lin. ft.	8.25	5/76
Power and non-powered spur 15' power, 30' gravity	Each	12,400	5/76
Additional Power	Lin. ft.	45.00	5/76
Additional non-power	Lin. ft.	8.25	5/76
Drive enclosure	Each	1,400	5/75
Fully powered spurs, to 30'	Each	13,650	5/76
Additional length	Lin. ft.	45.00	5/76
Drive enclosure	Each	1,400	5/76
In-feed merge controls	Each	2,200	5/76
Transfers, complete, to 45'	Each	15,850	5/76
Drive enclosure	Each	1,400	5/76
Chain crossover	Each	2,950	5/76
Accumulation stops	Each	1,025	5/76
Additional length	Lin. ft.	45.00	5/76
Miscellaneous			
Expansion joints	Each	85.00	5/76
Ramp track	Lin. ft.	3.25	5/76
Add 100' Rad. vertical curve	Each	1,120	5/76
Ramp controls	Each	385	5/76
Expansion joint-side finger	Each	230	5/76
Empty cart selector switch	Each	75	5/76
Blind chain return	Lin. ft.	25	5/76
Fire door diverter	Each	875	5/76
Spur Cleanout box	Each	85	5/76
Cart Unloader	Station	1,840	5/76
Photo-electric switching-add	Station	275	5/76

Prices are installed but do not include concrete work or field wiring.

Source: W&H Conveyor Systems, Inc. (SI)
Carlstadt, N.J.

TOWLINE CARTS

2,000 lbs. capacity towline carts with front stanchion and handle, bill holder, blackboard and 8x2 rubber tired wheels. Bumper, tow-pin and selector rack priced separately.

32"x48"	Wood deck	Each	187	5/76
	Steel deck	Each	148	5/76
	Composite deck	Each	158	5/76
32"x54"	Wood deck	Each	195	5/76
	Steel deck	Each	154	5/76
	Composite deck	Each	160	5/76
32"	Rigid bumper	Each	97	5/76
	Accumulating bumper	Each	108	5/76
	Accum. & Push bumper	Each	262	5/76
36"x54"	Wood deck	Each	204	5/76
	Steel deck	Each	159	5/76
	Composite deck	Each	168	5/76
36"x72"	Wood deck	Each	225	5/76
	Steel deck	Each	177	5/76
36"	Rigid bumper	Each	102	5/76
	Accumulating bumper	Each	113	5/76
	Accum. & Push bumper	Each	277	5/76
42"x60"	Wood deck	Each	228	5/76
	Steel deck	Each	186	5/76
42"x72"	Wood deck	Each	240	5/76
	Steel	Each	200	5/76
42"x84"	Wood deck	Each	249	5/76
	Steel deck	Each	240	5/76
42"	Rigid bumper	Each	110	5/76
	Accumulting bumper	Each	120	5/76
	Accum. & Push bumper	Each	289	5/76
48"x60"	Wood deck	Each	240	5/76
	Steel deck	Each	211	5/76
48"x72"	Wood deck	Each	254	5/76
	Steel deck	Each	229	5/76
48"x96"	Wood deck	Each	298	5/76
	Steel deck	Each	254	5/76
48"x108"	Wood deck	Each	326	5/76
	Steel deck	Each	269	5/76

TOWLINE CARTS

48"	Rigid bumper	Each	115	5/76
	Accumulating bumper	Each	126	5/76
	Accum. & Push bumper	Each	295	5/76

Bumper price includes tow-pin, selector rack and probes.

For 3,000# cart capacity add $33 per cart.

Prices FOB factory.

Source: W&H Conveyor Systems (SI)
Carlstadt, N.J.

TRACTORS

Item	Unit	$ cost	Date
Internal Combustion Engined Tractors			
DBP - 3,000# @ 2.2 MPH 1,400# @ 5 MPH 800# @ 9.5 MPH	Each	8,000	5/76
- 3,000# @ 6 MPH 1,000# @ 15 MPH	Each	9,300	5/76
Battery Powered Tractors			
DBP - 400#, Walk or Ride	Each	2,600- 3,200	10/76
Battery and Charger	Set	1,300	9/76
Battery Powered, Wire Guided Tractors			
DBP (24V) - 550# @ 2.8 MPH No Load 3.2 MPH (36V) - 1,290# @ 2.2 MPH No Load 2.8 MPH	Each	10,000- 12,000	5/76
Includes On Board Controls, no wire or stops			
Battery and Charger	Set	2,000	5/76
DBP - 600#, on Board Controls, No wire w/batteries	Each	6,000- 12,000	8/76
- 600#, on Board Controls, 2,500' Loop 15 stops w/batteries	System	30,000	7/76
- 400#, on Board Controls, 2,500' Loop 15 stops w/batteries	System	20,000	7/76
- 400#, Same except 2 tractors w/batteries	System	60,000	7/76
- 600#, Same except 2 tractors w/batteries	System	85,000	7/76
Guidance Wire, Installed Lin. Ft.		5-10	5/76

Sources: Clark Equipment Co., NY Office
Otis Material Handling Div., Cleveland, Ohio
J.B. Webb Co., Detroit, Mich.
Exide Power Systems Div., ESB, NY Office
Barrett Electronics Corp., Northbrook, ILL

WAREHOUSE TRAILERS

Item	Unit	$ cost	Date
Warehouse Trailers, Capy 2,000#			
Caster Steer, 8 x 2½ Rubber Tires			
Flush Wood Deck, Auto Couplers			
6 Unit Train Limit			
Lots of 100 or more			
48 x 60 Deck	Each	192	5/76
48 x 72 Deck	Each	198	5/76

Source: J.E. Coleman Co. (Jakes Foundry)
New York, NY

TUBE SYSTEMS & RELATED EQUIPMENT

Item	Unit	$ cost	Date
Pneumatic Tube Systems			
Point to Point, 50 ft. run			
4½" Ø tube	System	5,400	8/76
4"x7" tube	System	7,000	8/76
Automatic Switching System			
4" Ø tube	Station	7,000-8,000	8/76
4"x7" tube	Station	8,000-10,000	8/76
Side Opening Carriers	Each	10-15	8/76
Telelift Carrier System			
20# capy, 1 cu. ft.	Station	20,000-25,000	8/76
Carrier, Top Opening	Each	1,000	8/76

Prices shown are installed and wired.

Source: Mosler Airmatic Systems Div.
New York, NY

ELECTRONIC EQUIPMENT

Item	Unit	$ cost	Date
Fixed Beam Bar Code Scanner with Interface	Each	3,600-5,000	9/76
Automatic Laser Beam Scanner with Interface	Each	6,500-12,000	9/76
Micro-Processor with Wand	Each	900-2,500	7/76
Off-Line Wand Reader w/casette	Each	3,000	7/76
Label Printer	Each	5,000-10,000	7/76
Label Applicator, 120/min	Each	8,000-10,000	7/76
Label Printer-Applicator	Each	15,000-20,000	7/76
Voice Encoder with Interface	Each	10,500-18,750	9/76
4 Input Encoder System	System	32,250-60,000	9/76

Sources: Computer Identics, Westwood, MA
USPS, R&D Branch, Rockville, MD
Accu-sort, Inc., Sellersville, PA
Electronics Corp. of America, Cambridge, MA
Threshold Technology Inc., Delran, NJ
MRC Corp., Hunt Valley, MD
Scope Electronics, Reston, VA

WIRE CONTAINERS

Item	Unit	$ cost	Date
Folding Wire Storage Container			
32"x40"x28" high, 3000# capacity			
Drop gate on 32" side	Each	93.20	10/76
Drop gate on 40" side	Each	87.15	10/76
40"x48"x30" high, 4000# capacity			
Drop gate on 40" side	Each	110.55	10/76
Drop gate on 48" side	Each	106.85	10/76

FLOW RACKS

Item	Unit	$ cost	Date
Gravity Pallet Flow Rack			
Range, depending on size & weight	pallet pos.	60-120	5/76
For 500 pallets, 2,000#/pallet	pallet pos.	80	5/76
Case Flow Rack			
Heavy duty (40 lbs. per ft. per lane)			
20 ft. wide front 4 decks 48 lanes	ft. of lane	$6.67	11/76
Light duty 5 ft. wide front 5 decks 25 lanes	ft. of lane	$2.20- 2.40	11/76

Sources: Rapistan Incorporated
Piscataway, NJ 08854

North American Equipment Co.
Kenilworth, NJ

ADDENDUM

Item	Unit	Cost (dollars)
Dragline costs		
Straight track	Lineal feet	23
Turns	System	8,000
Drive	System	17,250
Drive enclosure	System	1,650
Field wiring	System	5,000
Nonpowered spur	Each	1,400
Cart	Each	300
Man-aboard S/R Unit-40 feet high		
S/R unit	Unit	35,000
Track, rail, etc,	Lineal feet	57
Transfer unit	Unit	30,000
Transfer unit rail	Lineal feet	65
Erection	Unit	2,000
System controls	System	150,000
Mobility system		
Transporter (equipped with communications package)	Unit	50,000
Carts	Each	750
Guide wire (includes computer link)	Lineal feet	6.60
Pallet racks		
45 feet high for turret truck	Each	32.60
60 feet high for ASRS unit	Each	98.05

Cantilever racks

Uprights

Under 10,000 pounds loading 24' high -- $205 each (Based on Interlake Type C upright $150 for upright + $55 for base.)

10,000 pounds loading 40' high -- $552 each (Based on Interlake Type G 24' high upright - $280/2x40'= 467 + 85 for base.)
24'

24,000 pounds loading 24' high -- $365 each (Based on Interlake Type G 24' high upright $280 + 85 = $365.)

40,000 pounds loading - 40' high -- $615 each (Based on Interlake Type K upright 336' high $360 + 480"= 515 + $100 for base.)
336"

Arm

12" -- $ 6 each
36" -- $10 each
48" -- $12 each
60" -- $14 each

Item	Unit	Cost[a] (dollars)
Cantilever racks (cont'd.)		
Bracing		
8' -- $14.00		
5.67' and 5.33' -- $12.50		
2.75' to 3.5' -- $11.50		
Forklift truck		
10,000 pound capacity, 24" load center	Each	36,000
2,000 pound capacity, 24" load center	Each	18,000
6,000 pound capacity, 24" load center	Each	30,000
4,000 pound capacity, standard CB 130" lift	Each	20,500
4,000 pound capacity, outrigger (30" lift)	Each	19,500
4,000 pound capacity, standard CB 187"-192" lift	Each	21,500
4,000 pound capacity, outrigger 187"-192" lift		20,800
4,000 pound capacity, 187"-192" lift	Each	21,800
Turret truck 45-foot high rack (includes battery and charger)	Each	73,000
ASRS unit (automatic) includes controls and rail	Each	125,000
ASRS transfer car includes rail	Each	50,000
Overhead crane		
10 ton capacity 80-foot span	Each	110,000
3 ton capacity 90-foot span	Each	105,000
3 ton capacity 95-foot span	Each	115,000
1 ton capacity 75-foot span	Each	75,000
1 ton capacity 80-foot span	Each	80,000
1 ton capacity 105-foot span	Each	85,000
1½ ton capacity 80-foot span	Each	100,000
1 ton capacity 80-foot span	Each	100,000
10 ton capacity 110-foot span	Each	155,000
1½ ton capacity 80-foot span	Each	100,000
3 ton capacity 110-foot span	Each	130,000
Crane runway	Lineal feet	310

[a]Forklift costs include battery and charger.

Item	Unit	Cost (dollars)
Man-ride tractor including battery and charger	Each	5,500
Electric palletjack including battery and charger	Each	3,500
Computer terminal with CRT and printer	Each	5,000
Pallet scale (4,000 pound capacity)	Each	5,200
40" x 48" GPC hardwood pallet	Each	6.50
Manual diverter	Each	2,500
Pallet conveyor (installed)	Lineal feet	160
Diverter chute	Each	100
Cube machine (installed)	Each	30,000
Packing station (includes bench, table scale, transfer)	Each	1,150
Intermediate level sprinkler	Square feet per level	2.50

EXHIBIT C

SPACE COSTS

Unit costs for space used in the development of nominal depot cost curves are those for new construction based on industrial estimates and adjusted to provide for geographic and building height variations.

The seven Schedules of Exhibit C show the unit space factors used and their development.

Schedule C-I is a listing of the space cost factors used for each type of space at varying building heights in three regional depot groupings.

Schedule C-II shows the primary source of each unit construction cost estimate.

Schedule C-III shows, by example, the calculations performed to develop unit space costs for geographic, building height, and storage mode differences from the primary source data.

Schedule C-IV shows, in list and graphic form, the factors used to develop cost factors reflecting building height variations.

Schedule C-V lists the regional groups of existing DOD depot locations and the geographic construction cost factor associated with each location and group.

Schedule C-VI is a description of the parameters upon which the general purpose conventional building cost is based.

Schedule C-VII is a description of the parameters upon which the rack-supported building cost is based.

Schedule C-I

Space Cost Summary

Building types and related clear heights (feet)	Clear height multiplier[a] Base	Clear height multiplier[a] Adjusted	Cost per square foot (by region)[b,d] (dollars) Group I	Group II	Group III
General purpose storage					
20	1.26	0.75	12.20	13.93	15.26
25	1.49	0.89	14.48	16.53	18.10
30	1.67	1.00	16.22	18.57	20.34
45	2.13	1.28	20.83	23.77	25.04
60	2.56	1.53	24.89	28.41	31.12
75	3.15	1.89	30.75	35.10	38.44
100	5.23	3.13	50.93	58.12	63.66
Cold storage					
20	1.26	0.75	26.84	30.64	33.56
25	1.49	0.89	31.85	36.36	39.83
30	1.67	1.00	35.79	40.85	44.75
45	2.13	1.28	45.81	52.29	57.28
60	2.56	1.53	54.76	62.50	68.47
Security storage					
15	1.00	0.60	11.62	13.26	14.52
20	1.26	0.75	14.52	16.58	18.15
30	1.67	1.00	19.25	22.10	24.20
Hazardous storage					
20	1.26	0.75	12.38	14.14	15.49
25	1.49	0.89	14.69	16.78	18.35
30	1.67	1.00	16.51	18.85	20.65
45	2.13	1.28	21.13	24.13	26.43
60	2.56	1.53	25.26	28.84	31.59
Rack-supported building[c] (ASRS)					
60	2.56	1.00	45.42	51.61	56.77
75	3.15	1.23	55.87	63.48	69.83
100	5.23	2.04	92.66	105.28	115.81
Rack-supported building[c] (high-density storage)					
60	2.56	1.00	58.36	66.32	72.95
75	3.15	1.23	71.78	81.57	89.73
100	5.23	2.04	119.06	135.29	148.82

[a] From Schedule C-IV.
[b] From Schedules C-II, C-III, and C-V.
[c] Rack-supported building costs include cost of racks.
[d] If intermediate sprinklers are required, add $1.25 per square foot for each intermediate sprinkler level.

Schedule C-II

Construction Cost Estimates

	Source	Date	Building geographical location	Type of storage	Design parameters	Cost estimate (dollars/square foot)
1.	Air Force Institute of Technology (AFIT), Wright-Patterson Air Force Base, Ohio Report GCE/MC/76S-1, "A General Warehouse Module Conceptual Design and Cost Analysis"	9/76	Norfolk, Virginia	General purpose	Schedule C-VI	16.00
2.	Same as no. 1	9/76	Norfolk, Virginia	Cold[a]	30 feet clear height, 34,000 square feet	35.15
3.	Same as no. 1	9/76	Norfolk, Virginia	Security (vault type)	30 feet clear height, 32,000 square feet	19.00
4.	Helmer-Cronin Construction Company, Stony Point, New York	4/11/77	New York Metropolitan	General purpose	Schedule C-VI	19.00
5.	Abbott, Merkt and Company New York, New York	5/13/77	Washington, D.C.	General purpose	Schedule C-VI	16.90
6.	Abbott, Merkt and Company New York, New York	5/18/77	Washington, D.C.	Hazardous	Schedule C-VI with explosion-proof electrical fixtures	17.15[b]
7.	Wisconsin Bridge and Iron Company Milwaukee, Wisconsin	7/11/77	Regional Group II	General purpose Rack-supported building	Schedule C-VII	51.61[c]
8.	Drake Sheahan/Stewart Dougall Inc. New York, New York	8/9/77	Regional Group II	Same as no. 7	Schedule C-VII with high-density storage system replacing ASR System	66.32[d]

[a] 33 percent freeze space, 67 percent chill space.

[b] Reflects a 30 percent increase in electrical equipment cost. Electrical cost is assumed to be 5 percent of total building cost (16.90) /1 + (0.30) (0.05)_7 = 17.15.

[c] Includes cost of racks.

[d] Derived from basic rack-supported building cost assuming 50 percent additional storage capacity (racks).

Schedule C-III

Sample Calculations

1. Selection of base cost for general purpose storage from various sources:

Source cost[a] (dollars per square foot)	Location	Location factor[b]	Adjusted cost (dollars per square foot)
16.00	Norfolk, Virginia	0.82	19.51
19.00	New York, New York	1.14	16.66
16.90	Washington, D.C.	1.00	16.90

Selection: average value = 17.69

2. Regionalization:

Base cost	Region	Regional factor[b]	Regional cost
17.69	I	0.92	16.27
	II	1.05	18.57
	III	1.15	20.34

3. Building height:

30-foot clear height base cost = $17.69 per square foot.
Cost per square foot for 25 feet = (17.69)(1.49/1.67)[c] = $15.78.
Cost per square foot for 60 feet = (17.69)(2.56/1.67)[c] = $27.12.

4. Special storage modes:

Cold storage
Multiplier is (35.15/16.00)[d] = 2.20.

Security storage
Multiplier is (19.00/16.00)[d] = 1.19.

Hazardous storage
Multiplier is (17.15/16.90)[d] = 1.015.

These multipliers are to be applied to general purpose storage base cost in addition to application of regional and height factors.

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[a] From Schedule C-II.
[b] From Schedule C-V.
[c] From Schedule C-IV.
[d] From Schedule C-II.

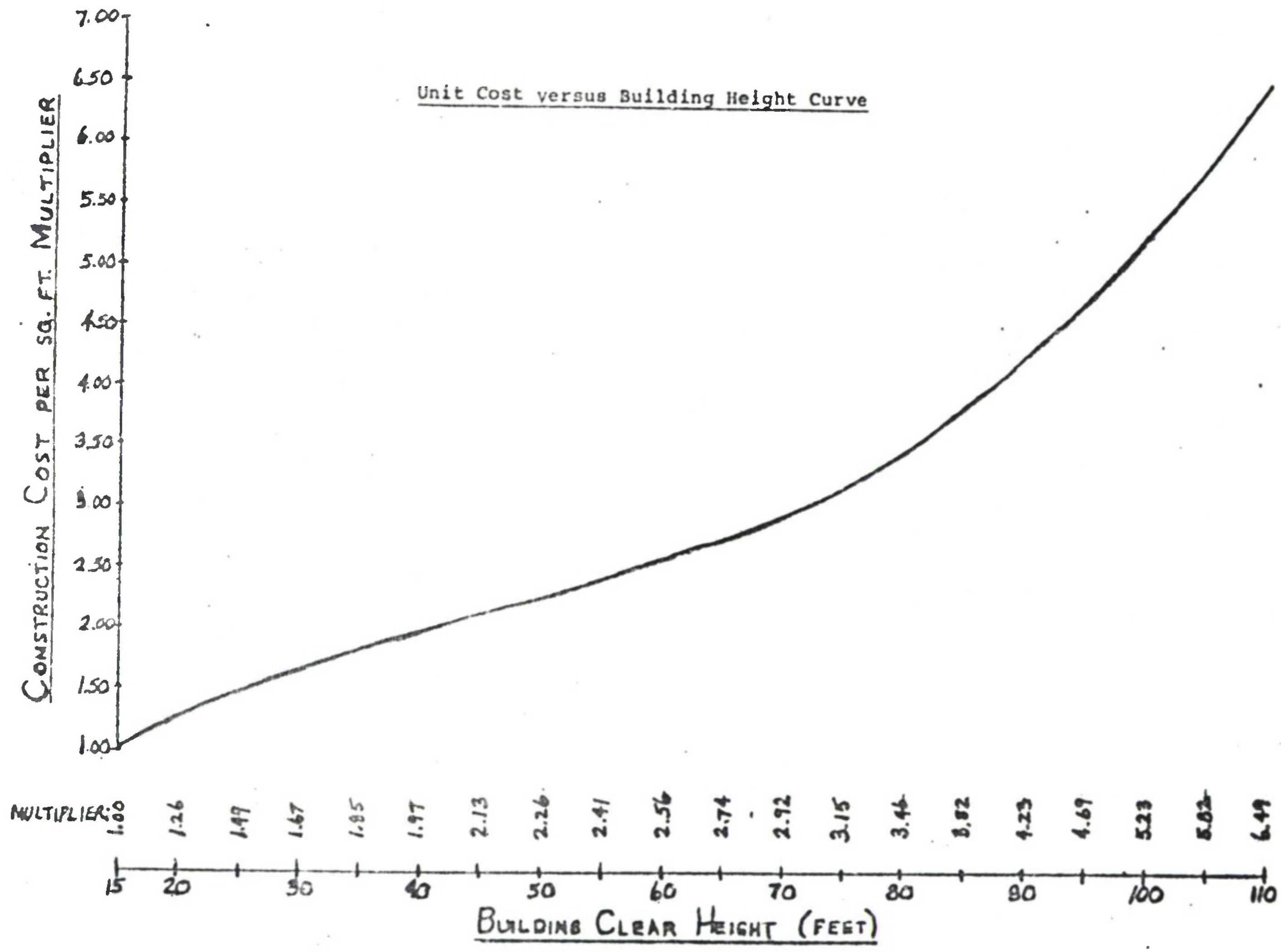
Schedule C-IV

Unit Construction Cost/Building Height Relationship

The graph and table included in this Schedule can be used to estimate the warehouse construction cost per square foot for a building of any given clear height. Both show in different format construction cost multipliers for warehouses with clear heights ranging from 15 feet to 110 feet. They were derived from cost data from four sources:

MODERN MATERIALS HANDLING, February 1974
MATERIAL HANDLING ENGINEERING, February 1974
Clark Storage Systems, Brochure
Interlake, Brochure

If the cost per square foot for a specified height warehouse is known, the graph or table can be used to estimate the cost per square foot for any other height.


Unit Cost versus Building Height Curve
Construction Cost per Sq. Ft. Multiplier
7.00
6.50
6.00
5.50
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
Multiplier: 1.00
1.26
1.49
1.67
1.85
1.97
2.13
2.26
2.41
2.56
2.74
2.92
3.15
3.46
3.82
4.25
4.69
5.23
5.82
6.49
15
20
30
40
50
60
70
80
90
100
110
Building Clear Height (Feet)

Unit Construction Cost/Building Height Table

Building clear height (feet)	Unit construction cost factor
15	1.00
20	1.26
25	1.49
30	1.67
35	1.85
40	1.97
45	2.13
50	2.26
55	2.41
60	2.56
65	2.74
70	2.92
75	3.15
80	3.46
85	3.82
90	4.23
95	4.69
100	5.23
105	5.82
110	6.49

Schedule C-V

Construction Cost Regional Groupings

Group I	Location	Depot	Index[a]	
	Scranton, PA	TOAD	1.01	
	Birmingham, AL	ANAD	0.86	
	Texarkana, TX	RRAD	0.90	
	Lexington, KY	LBAD	0.90	
	Harrisburg, PA	LEAD	0.99	
	Richmond, VA	DGSC	1.00	
	Memphis, TN	DDMT	1.00	
	Albany, GA	MCLSB(AL)	0.82	
	Norfolk, VA	NSC(NDR)	0.82	
	Norfolk, VA	NAS(NDR)	0.82	
	San Antonio, TX	SAALC	0.95	
			Group I average	0.92
Group II	Harrisburg, PA	NCAD	0.99	
	Pueblo, CO	PUAD	1.05	
	Tooele, UT	TEAD	1.20	
	Corpus Christi, TX	CCAD	0.95	
	Oklahoma City, OK	OCALC	1.01	
	Ogden, UT	OOALC	1.20	
	Macon, GA	WRALC	0.82	
	Harrisburg, PA	DDMP	0.99	
	Columbus, OH	DCSC	0.94	
	Ogden, UT	DDOU	1.20	
	San Diego, CA	NAS(NI)	1.15	
	San Diego, CA	NSC(SD)	1.15	
	New Bern, NC	MCAS(CP)	1.00	
			Group II average	1.05
Group III	Stockton, CA	SHAD	1.19	
	Sacramento, CA	SAAD	1.19	
	Sacramento, CA	SMALC	1.19	
	Stockton, CA	DDTC	1.19	
	Dayton, OH	DESC	1.[illegible]	
	Jacksonville, FL	NAS(JAX)	0.95	
	Barstow, CA	MCLSB(B)	1.17	
	Pearl Harbor, HI	NSC(PH)	1.30	
	Oakland, CA	NSC(OAK)	1.03	
	Oakland, CA	NAS(ALAM)	1.09	
			Group III average	1.15
	New York, NY		1.14	

[a] F.W. Dodge Regional Construction Cost Index, March 1976, Washington, D.C. = Base 1.00.

Schedule C-VI

Characteristics of Typical General Purpose Storage and Processing Facility

Assumptions:

The site will be reasonably flat, requiring minimal preparation.

Sewers, power, and water are available up to the building.

Yard work and paving are excluded from consideration.

The building will be used for receiving, preserving, packing, storage, and shipping of miscellaneous supplies falling under NFPA Classifications I, II, III, and IV.

The normal population is expected to be 400 persons -- 50 percent male, 50 percent female.

Size:

The building will be approximately 500,000 square feet in area, approximately square, with a clear stacking height of 30 feet. Column spacing will be 40 x 60 or 60 x 60.

Construction:

Building frame to be steel on spread footings. Roof is to be 20 ga. steel decking with 15/16 inch fibreglass and 1.25 inch urethane insulation. Roofing is to be four-ply built-up asphalt and felt paper with aggregate covering. In addition to normal loadings, 100,000 square feet of the framing shall be stressed to support conveyors with a maximum loading of 20 pounds per square foot. Exterior walls are to be tilt slab up to 20 feet with insulated metal panels above. Floor to be slab on grade designed for 500 pounds per square foot, troweled smooth and sealed.

Interior divisions:

Approximately 100,000 square feet will be utilized for shipping, receiving, and processing. Of this, 5,000 square feet will be used as offices, toilets, and related activities. This area will house the hanging conveyors.

Approximately 100,000 square feet will be devoted to highly mechanized storage equipment.

The balance will be devoted to general storage, bulk and racked.

All storage areas will be separated into blocks not exceeding 80,000 square feet by six-hour rated walls extending three feet above the roof, with appropriate connecting fire doors.

Transportation:

Enclosed truck docks to accommodate 30 trucks will be provided in two groups of 15 each, 60 feet deep. Motorized hydraulic dock levelers will be provided at each position.

One enclosed five-car (350 feet) siding along an exterior wall will be provided.

Electrical service:

Incoming electrical service will be primary power. The total building load is expected to be approximately 2,500 KW. Transformers, switchgear, and a distribution system will be required for lighting, HVAC equipment, and materials handling equipment.

Lighting:

Excepting offices and limited specialized processing areas, lighting fixtures will be mounted 30 feet above the floor, and may be high-pressure sodium or mercury vapor. Offices and processing areas are to be fluorescent. Lighting levels, measured 2½ feet above the floor, will be:

	Foot-candles
Offices	100
Shipping, receiving, and processing	50
Storage areas	20
Truck docks	5

HVAC:

The shipping and receiving and mechanized storage areas (200,000 square feet) are to be air-conditioned with a 65°-80° range and ventilation of ten percent per hour. In addition, the Mechanized Storage Area (100,000 square feet) is to have controlled humidity -- not to exceed 50 percent relative.

The General Storage Area (300,000 square feet) is heated and ventilated only -- with fan capacity of two changes per hour. Minimum temperature to be $55^{\circ}F$. Steam or hot water unit heaters are to be used.

Plumbing:

Roof drains connected to the storm sewer are required. Necessary toilets, drinking fountains, and other domestic water and sanitary sewer facilities are to be provided.

Fire protection:

Ceiling sprinklers are to be provided throughout with a density of 100 square feet per head. A high-pressure loop is to be provided with necessary risers and valves plus booster pump, and with hose connections within the building -- one per 10,000 square feet. Riser capacity (separate) is required for eventual in-rack sprinklers.

Interior finishes:

The entire interior is to be painted -- framing, roof deck, walls, plus all piping. Offices and personnel areas will receive normal office level treatment such as acoustical ceiling, floor tile, etc.

Schedule C-VII

Characteristics of Typical Rack-supported Storage Facility

Assumptions:

Site will require a minimum of preparation.

Work is limited to the storage building.

The racks will be used in conjunction with storage and retrieval machines operating on rails, with fully automated controls, 12 aisles -- 300 feet long, 13 high.

Size:

The building will comprise approximately 100,000 square feet, with a usable rack height of 60 feet.

Construction:

The building roof and exterior skin will be fully supported by the rack structure. Racks shall be designed to accommodate unit loads 40" x 48" x 42" with a maximum weight of 2,500 pounds.

Transportation:

Movement in and out of the building will be by pallet conveyor.

Electrical service:

Sufficient power will be provided to operate the AS&R machines and conveyors.

Lighting:

No area lighting is required. Local lighting at transfer stations for maintenance purposes will be required.

HVAC:

Only sufficient heat to protect the sprinkler system will be provided.

Plumbing:

Roof drains connecting to storm sewers only.

Fire protection:

Two sprinkler systems shall be provided. One shall be ceiling mounted with a density of 100 square feet per head. The second shall serve the rack-mounted intermediate sprinklers with 240 heads per aisle per sprinkler level.

EXHIBIT D

LABOR RATES

For development of nominal state-of-the-art depot operating cost curves, effective hourly labor rates are used. One rate is used for all warehouse functions within each regional grouping of depots. This effective hourly rate includes the basic hourly wage of workers, the basic hourly rate of first-line supervisors, all fringe benefits, and an inflation factor to normalize the rates to a 1976 value.

The four Schedules included in this Exhibit show the base information used and all calculations employed to develop the effective rate for each of the three regional depot groupings.

Schedule D-I is a summary of the three regional rates used in normal cost curve development, on an hourly basis and extended to obtain annual costs.

Schedule D-II shows the calculations performed to transform Fiscal Year 1975 hourly rates into Fiscal Year 1976 effective hourly rates.

Schedule D-III is a listing of the 34 depots being studied by the DODMDS Study Group by depot and/or regional grouping, and the basic average hourly labor rate for each grouping.

Schedule D-IV is a listing of civilian pay inflation factors (indices) from 1960 to 1986.

Schedule D-I

Effective Hourly Labor Rates

For nominal cost curve development, the following hourly labor costs are used:

Regional Group I -- $7.43
Regional Group II -- $7.95
Regional Group III -- $8.82

Extending the hourly rates to obtain annual labor costs:

Regional Group I -- $7.43 x 2,008[a] = $14,920.
Regional Group II -- $7.95 x 2,008[a] = $15,964.
Regional Group III -- $8.82 x 2,008[a] = $17,711.

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[a]251 working days per year times 8 hours per day = 2,008 hours per year.

Schedule D-II

Labor Cost Calculations

Given: Fiscal Year 1975 productive hourly wage rates:

Regional Group I -- \$6.35)
Regional Group II -- \$6.80)from Schedule D-III.
Regional Group III -- \$7.54)

1975-1976 inflation factor: 1.08.
From Schedule D-IV.

Labor/supervisor ratio: 12:1[a].
From Schedule A-II, Planning Assumptions.

Calculations:

Fiscal Year 1975 hourly rate x 1975-76 inflation factor x supervisory factor (13/12) = effective hourly wage rate to be used for nominal cost curve development.

Regional Group I -- \$6.35 x 1.08 x 1.083 = \$7.43.
Regional Group II -- \$6.80 x 1.08 x 1.083 = \$7.95.
Regional Group III -- \$7.54 x 1.08 x 1.083 = \$8.82.

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[a] For every 12 men working, one first-line supervisor is needed.

Schedule D-III

Labor Cost Regional Groupings

	Group I	Group II	Group III
	TOAD	NCAD	SHAD
	ANAD	PUAD	SAAD
	RRAD	TEAD	SMALC
	LBAD	CCAD	DDTC
	LEAD	OCALC	DESC
	DGSC	OOALC	NAS (JAX)
	DDMT	WRALC	MCLSB (B)
	MCLSB-AL	DDMP	NSC (PH)
	NSC-NORF	DCSC	NSC (OAK)
	NAS-NORF	DDCU	NAS (ALAM)
	SAALC	NAS-NI	
		NSC-SD	
		MCAS-CP	
Average hourly rate:[a]	\$6.35	\$6.80	\$7.54

[a]Fiscal Year 1975 productive hourly wage rate including fringe benefits and first-line supervision. Source: DODMDS System Cost and Performance Task Group.

Schedule D-IV

Civilian Pay Indices

Year	Annual index values (base year 1975)	Annual index values (base year 1976)
1960	45	42
1961	48	45
1962	49	45
1963	50	47
1964	52	49
1965	55	51
1966	56	52
1967	58	54
1968	60	56
1969	64	60
1970	71	66
1971	76	71
1972	82	76
1973	86	80
1974	92	86
1975	100	93
1976	108	100
1977	116	107
1978	123	114
1979	130	121
1980	138	129
1981	147	136
1982	157	146
1983	167	156
1984	179	166
1985	191	178
1986	204	190

Source: Department of Defense Deflators (Outlays), Office of the Assistant Secretary of Defense (Comptroller), 28 January 1976.

EXHIBIT E

FLOW PATH COST SUMMARIES

The direct variable costs for handling and storing materiel at various levels of throughput volume are shown in the tables of this Exhibit. Annual costs for each of the 11 flow paths are shown for 40 levels of throughput and for the three regions or depot groupings.

The costs shown include annual labor and supplies costs, and annualized costs for space and equipment.

COST CURVE SUMMARY

Flow path 1

Throughput volume level		Total annual cost (thousands of dollars)		
No. of depots[a]	Total annual throughput volume (1,000 hundredweight)	Region I	Region II	Region III
40	.15	27	27	28
39	.15	27	27	29
38	.16	28	28	29
37	.16	28	28	30
36	.17	29	29	30
35	.17	29	29	30
34	.18	29	29	31
33	.18	30	30	31
32	.19	30	30	32
31	.19	31	31	32
30	.20	31	31	33
29	.21	32	32	34
28	.21	33	33	34
27	.22	33	33	35
26	.23	34	34	36
25	.24	35	35	36
24	.25	36	36	37
23	.26	37	37	38
22	.27	38	38	39
21	.29	39	39	41

[a]Refers to DS/SD flow path data sets and calculations: 1 depot means total system throughput; 2 depots means total system throughput divided by 2; 3 depots means total system throughput divided by 3; etc.

COST CURVE SUMMARY

Flow path 1

Throughput volume level		Total annual cost (thousands of dollars)		
No. of depots[a]	Total annual throughput volume (1,000 hundredweight)	Region I	Region II	Region III
20	.30	40	40	42
19	.31	41	42	43
18	.33	43	43	45
17	.35	45	45	47
16	.38	47	47	49
15	.40	49	49	51
14	.43	51	51	53
13	.46	54	54	56
12	.50	57	58	60
11	.55	61	62	64
10	.60	66	66	69
9	.67	72	72	75
8	.75	79	79	82
7	.86	88	89	92
6	1.00	101	101	104
5	1.20	118	119	122
4	1.50	144	145	149
3	2.00	188	188	194
2	3.00	275	276	283
1	6.00	535	537	550

[a]Refers to DS/SD flow path data sets and calculations: 1 depot means total system throughput; 2 depots means total system throughput divided by 2; 3 depots means total system throughput divided by 3; etc.

COST CURVE SUMMARY

Flow path 2

Throughput volume level		Total annual cost (thousands of dollars)		
No. of depots[a]	Total annual throughput volume (1,000 hundredweight)	Region I	Region II	Region III
40	23.0	41	44	47
39	23.5	42	45	47
38	24.2	42	45	48
37	24.8	42	46	48
36	25.5	43	46	49
35	26.2	43	47	50
34	27.0	44	47	50
33	27.8	45	48	51
32	28.7	45	49	52
31	29.6	46	49	52
30	30.6	46	50	53
29	31.7	47	51	54
28	32.8	48	52	55
27	34.0	49	53	56
26	35.3	50	54	57
25	36.7	51	55	58
24	38.3	52	56	60
23	39.9	53	57	61
22	41.7	54	59	62
21	43.7	56	60	64

[a]Refers to DS/SD flow path data sets and calculations: 1 depot means total system throughput; 2 depots means total system throughput divided by 2; 3 depots means total system throughput divided by 3; etc.

COST CURVE SUMMARY

Flow path 2

Throughput volume level		Total annual cost (thousands of dollars)		
No. of depots[a]	Total annual throughput volume (1,000 hundredweight)	Region I	Region II	Region III
20	45.9	57	62	66
19	48.3	59	63	68
18	51.0	61	66	70
17	54.0	63	68	73
16	57.4	65	70	75
15	61.2	68	73	78
14	65.6	71	77	82
13	70.6	75	80	86
12	76.5	79	85	91
11	83.5	84	90	97
10	91.8	89	96	104
9	102.0	97	104	112
8	114.8	106	114	123
7	131.1	117	126	136
6	153.0	132	143	154
5	183.6	154	166	179
4	229.5	186	200	217
3	306.0	240	258	280
2	459.0	347	374	406
1	918.0	669	720	785

[a]Refers to DS/SD flow path data sets and calculations: 1 depot means total system throughput; 2 depots means total system throughput divided by 2; 3 depots means total system throughput divided by 3; etc.

COST CURVE SUMMARY

Flow path 3

Throughput volume level		Total annual cost (thousands of dollars)		
No. of depots[a]	Total annual throughput volume (1,000 hundredweight)	Region I	Region II	Region III
40	3.1	72	75	80
39	3.1	72	75	80
38	3.2	72	75	80
37	3.3	73	76	81
36	3.4	73	76	81
35	3.5	73	76	82
34	3.6	74	77	82
33	3.7	74	77	83
32	3.8	75	78	83
31	3.9	75	78	84
30	4.1	76	79	85
29	4.2	76	80	85
28	4.4	77	80	86
27	4.5	77	81	87
26	4.7	78	82	87
25	4.9	79	83	88
24	5.1	80	83	89
23	5.3	81	84	90
22	5.5	82	85	91
21	5.8	83	87	93

[a]Refers to DS/SD flow path data sets and calculations: 1 depot means total system throughput; 2 depots means total system throughput divided by 2; 3 depots means total system throughput divided by 3; etc.

COST CURVE SUMMARY

Flow path 3

Throughput volume level		Total annual cost (thousands of dollars)		
No. of depots[a]	Total annual throughput volume (1,000 hundredweight)	Region I	Region II	Region III
20	6.1	84	88	94
19	6.4	85	89	96
18	6.8	87	91	98
17	7.2	89	93	99
16	7.6	90	94	101
15	8.1	92	97	104
14	8.7	95	99	107
13	9.4	98	102	110
12	10.2	101	106	114
11	11.1	105	110	118
10	12.2	109	115	123
9	13.6	115	121	130
8	15.3	122	128	138
7	17.4	130	138	148
6	20.3	142	150	162
5	24.4	159	169	182
4	30.5	184	195	211
3	46.7	226	240	260
2	61.0	309	330	357
1	122.0	560	599	649

[a]Refers to DS/SP flow path data sets and calculations: 1 depot means total system throughput; 2 depots means total system throughput divided by 2; 3 depots means total system throughput divided by 3; etc.

COST CURVE SUMMARY

Flow path 4

Throughput volume level		Total annual cost (thousands of dollars)		
No. of depots[a]	Total annual throughput volume (1,000 hundredweight)	Region I	Region II	Region III
40	4.1	48	51	52
39	4.2	49	52	53
38	4.3	50	53	54
37	4.4	51	54	55
36	4.5	52	55	56
35	4.6	54	56	58
34	4.8	55	58	59
33	4.9	56	59	61
32	5.1	58	61	62
31	5.2	59	62	64
30	5.4	61	64	66
29	5.6	62	66	68
28	5.8	64	68	70
27	6.0	66	70	72
26	6.2	68	72	74
25	6.5	70	74	77
24	6.8	73	77	80
23	7.0	75	80	83
22	7.4	78	83	86
21	7.7	81	86	90

[a]Refers to DS/SD flow path data sets and calculations: 1 depot means total system throughput; 2 depots means total system throughput divided by 2; 3 depots means total system throughput divided by 3; etc.

COST CURVE SUMMARY

Flow path 4

Throughput volume level		Total annual cost (thousands of dollars)		
No. of depots[a]	Total annual throughput volume (1,000 hundredweight)	Region I	Region II	Region III
20	8.1	85	90	94
19	8.5	89	94	98
18	9.0	93	99	103
17	9.5	98	104	109
16	10.1	103	109	115
15	10.8	109	116	122
14	11.6	116	123	130
13	12.5	124	132	140
12	13.5	133	142	151
11	14.7	144	154	164
10	16.2	158	168	179
9	18.0	174	185	198
8	20.3	194	207	222
7	23.1	220	234	252
6	27.0	255	272	292
5	32.4	303	323	349
4	40.5	376	401	434
3	54.0	498	531	576
2	81.0	740	791	859
1	162.0	1,469	1,569	1,709

[a]Refers to DS/SD flow path data sets and calculations: 1 depot means total system throughput; 2 depots means total system throughput divided by 2; 3 depots means total system throughput divided by 3; etc.

COST CURVE SUMMARY

Flow path 5

Throughput volume level		Total annual cost (thousands of dollars)		
No. of depots[a]	Total annual throughput volume (1,000 hundredweight)	Region I	Region II	Region III
40	26.3	137	142	153
39	27.0	138	143	154
38	27.7	139	144	155
37	28.5	140	146	156
36	29.3	142	147	158
35	30.1	143	149	159
34	31.0	144	150	161
33	31.9	146	152	163
32	32.9	148	153	164
31	34.0	149	155	166
30	35.1	151	157	168
29	36.3	153	159	171
28	37.6	155	161	173
27	39.0	158	164	175
26	40.5	160	166	178
25	42.1	163	169	181
24	43.9	166	172	184
23	45.8	169	175	188
22	47.9	172	179	191
21	50.1	176	183	196

[a]Refers to DS/SD flow path data sets and calculations: 1 depot means total system throughput; 2 depots means total system throughput divided by 2; 3 depots means total system throughput divided by 3; etc.

COST CURVE SUMMARY

Flow path 3

Throughput volume level		Total annual cost (thousands of dollars)		
No. of depots[a]	Total annual throughput volume (1,000 hundredweight)	Region I	Region II	Region III
20	52.7	180	187	200
19	55.4	185	192	205
18	58.5	190	197	211
17	61.9	196	203	217
16	65.8	202	210	224
15	70.2	210	217	232
14	75.2	218	226	241
13	81.0	227	236	251
12	87.8	239	247	263
11	95.7	252	261	278
10	105.3	268	277	295
9	117.0	287	298	316
8	131.6	311	323	343
7	150.4	343	355	377
6	175.5	384	398	422
5	210.6	443	458	485
4	263.3	530	548	580
3	351.0	676	699	739
2	526.5	967	999	1,055
1	1,053.0	1,841	1,902	2,006

[a]Refers to DS/SD flow path data sets and calculations: 1 depot means total system throughput; 2 depots means total system throughput divided by 2; 3 depots means total system throughput divided by 3; etc.

COST CURVE SUMMARY

Flow path 6

Throughput volume level		Total annual cost (thousands of dollars)		
No. of depots[a]	Total annual throughput volume (1,000 hundredweight)	Region I	Region II	Region III
40	23.7	177	189	206
39	24.3	179	191	208
38	24.9	181	194	210
37	25.6	184	196	213
36	26.3	186	198	215
35	27.1	188	201	218
34	27.9	191	204	221
33	28.7	194	207	224
32	29.6	197	210	227
31	30.6	200	213	231
30	31.6	203	216	235
29	32.7	206	220	239
28	33.9	210	224	243
27	35.1	214	228	248
26	36.5	219	233	252
25	37.9	223	238	258
24	39.5	228	243	264
23	41.2	234	249	270
22	43.1	240	256	277
21	45.1	247	263	284

[a]Refers to DS/SD flow path data sets and calculations: 1 depot means total system throughput; 2 depots means total system throughput divided by 2; 3 depots means total system throughput divided by 3; etc.

COST CURVE SUMMARY

Flow path 6

Throughput volume level		Total annual cost (thousands of dollars)		
No. of depots[a]	Total annual throughput volume (1,000 hundredweight)	Region I	Region II	Region III
20	47.4	254	271	292
19	49.9	262	279	302
18	52.7	271	289	312
17	55.8	281	299	323
16	59.3	292	311	336
15	63.2	305	325	350
14	67.7	319	340	367
13	72.9	336	358	386
12	79.0	356	379	408
11	86.2	379	404	434
10	94.8	407	433	466
9	105.3	441	469	505
8	118.5	483	514	553
7	135.4	538	572	615
6	158.0	610	650	697
5	189.6	712	758	813
4	237.0	865	921	986
3	316.0	1,120	1,192	1,276
2	474.0	1,629	1,733	1,854
1	948.0	3,157	3,359	3,589

[a]Refers to DS/SD flow path data sets and calculations: 1 depot means total system throughput; 2 depots means total system throughput divided by 2; 3 depots means total system throughput divided by 3; etc.

COST CURVE SUMMARY

Flow path 7

Throughput volume level		Total annual cost (thousands of dollars)		
No. of depots[a]	Total annual throughput volume (1,000 hundredweight)	Region I	Region II	Region III
40	155	762	833	899
39	159	771	843	910
38	163	780	852	921
37	168	791	864	934
36	172	800	875	944
35	177	810	887	958
34	182	822	899	971
33	187	833	911	984
32	194	848	928	1,003
31	200	861	943	1,018
30	206	875	957	[illegible]
29	215	892	977	1,055
28	222	907	994	1,074
27	230	926	1,014	1,094
26	239	945	1,036	1,118
25	249	967	1,060	1,144
24	259	989	1,085	1,171
23	270	1,014	1,112	1,201
22	282	1,040	1,141	1,232
21	296	1,076	1,175	1,269

[a]Refers to DS/SD flow path data sets and calculations: 1 depot means total system throughput; 2 depots means total system throughput divided by 2; 3 depots means total system throughput divided by 3; etc.

COST CURVE SUMMARY

Flow path 7

Throughput volume level		Total annual cost (thousands of dollars)		
No. of depots[a]	Total annual throughput volume (1,000 hundredweight)	Region I	Region II	Region III
20	310	1,102	1,210	1,306
19	326	1,130	1,241	1,340
18	344	1,161	1,276	1,378
17	366	1,198	1,316	1,422
16	388	1,237	1,360	1,468
15	414	1,282	1,411	1,522
14	443	1,332	1,465	1,582
13	477	1,389	1,530	1,652
12	518	1,457	1,606	1,734
11	564	1,535	1,693	1,829
10	620	[illegible]	1,800	1,944
9	690	1,762	1,945	2,099
8	776	1,925	2,125	2,294
7	887	2,133	2,355	2,543
6	1,034	2,410	2,661	2,874
5	1,242	2,800	3,092	3,340
4	1,552	3,313	3,658	3,950
3	2,070	4,340	4,783	5,162
2	3,104	6,311	6,952	7,514
1	6,208	11,950	13,157	14,196

[a]Refers to DS/SB flow path data sets and calculations: 1 depot means total system throughput; 2 depots means total system throughput divided by 2; 3 depots means total system throughput divided by 3; etc.

COST CURVE SUMMARY

Flow path 8

Throughput volume level		Total annual cost (thousands of dollars)		
No. of depots[a]	Total annual throughput volume (1,000 hundredweight)	Region I	Region II	Region III
40	12.6	70	76	85
39	12.9	71	77	86
38	13.2	72	78	87
37	13.6	73	80	89
36	13.9	74	81	90
35	14.3	76	82	91
34	14.8	77	84	93
33	15.2	78	85	95
32	15.7	80	87	96
31	16.2	81	88	98
30	16.7	83	90	100
29	17.3	85	92	102
28	17.9	87	94	104
27	18.6	89	96	107
26	19.3	91	99	109
25	20.1	93	101	112
24	20.9	96	104	115
23	21.8	98	107	118
22	22.8	101	110	122
21	23.9	105	114	126

[a]Refers to DS/SD flow path data sets and calculations: 1 depot means total system throughput; 2 depots means total system throughput divided by 2; 3 depots means total system throughput divided by 3; etc.

COST CURVE SUMMARY

Flow path 8

Throughput volume level		Total annual cost (thousands of dollars)		
No. of depots[a]	Total annual throughput volume (1,000 hundredweight)	Region I	Region II	Region III
20	25.1	108	118	130
19	26.4	112	122	135
18	27.9	117	127	140
17	29.5	122	132	146
16	31.4	128	138	153
15	33.5	134	145	160
14	35.9	141	153	169
13	38.6	150	162	179
12	41.8	159	173	190
11	45.6	171	185	204
10	50.2	185	200	220
9	55.8	202	218	240
8	62.8	223	241	265
7	71.7	250	271	297
6	83.7	287	310	340
5	100.4	338	365	400
4	125.5	414	448	490
3	167.3	541	585	640
2	251.0	796	861	941
1	502	1,560	1,686	1,841

[a]Refers to DS/SD flow path data sets and calculations: 1 depot means total system throughput; 2 depots means total system throughput divided by 2; 3 depots means total system throughput divided by 3; etc.

COST CURVE SUMMARY

Flow path 9

Throughput volume level		Total annual cost (thousands of dollars)		
No. of depots[a]	Total annual throughput volume (1,000 hundredweight)	Region I	Region II	Region III
40	281	240	255	276
39	288	242	257	278
38	296	249	264	287
37	304	255	271	294
36	312	263	277	303
35	321	270	289	312
34	331	277	297	321
33	341	286	305	331
32	351	294	314	340
31	362	303	325	351
30	375	312	333	362
29	387	[illegible]	[illegible]	375
20	401	332	355	387
27	416	344	366	398
26	432	355	381	413
25	449	369	394	427
24	468	381	408	442
23	489	396	424	459
22	511	411	440	479
21	535	430	458	498

[a]Refers to DS/SD flow path data sets and calculations: 1 depot means total system throughput; 2 depots means total system throughput divided by 2; 3 depots means total system throughput divided by 3; etc.

COST CURVE SUMMARY

Flow path 9

Throughput volume level		Total annual cost (thousands of dollars)		
No. of depots[a]	Total annual throughput volume (1,000 hundredweight)	Region I	Region II	Region III
20	562	447	476	520
19	591	465	498	541
18	624	488	520	568
17	661	510	546	596
16	702	538	575	626
15	749	568	607	661
14	803	595	638	694
13	864	632	679	740
12	936	677	726	790
11	1,022	730	780	851
10	1,124	787	845	922
9	1,249	865	924	1,013
8	1,405	948	1,015	1,109
7	1,605	1,065	1,138	1,247
6	1,873	1,209	1,291	1,415
5	2,247	1,329	1,520	1,666
4	2,809	1,626	1,847	2,022
3	3,746	2,123	2,365	2,591
2	5,619	3,110	3,336	3,656
1	11,237	6,511	6,971	7,647

[a]Refers to DS/SD flow path data sets and calculations: 1 depot means total system throughput; 2 depots means total system throughput divided by 2; 3 depots means total system throughput divided by 3; etc.

COST CURVE SUMMARY

Flow path 10

Throughput volume level		Total annual cost (thousands of dollars)		
No. of depots[a]	Total annual throughput volume (1,000 hundredweight)	Region I	Region II	Region III
40	168	4,797	5,184	5,511
39	172	4,830	5,217	5,546
38	176	4,882	5,273	5,606
37	181	4,937	5,332	5,671
36	186	4,994	5,395	5,738
35	192	5,055	5,461	5,808
34	197	5,119	5,532	5,885
33	203	5,189	5,606	5,963
32	209	5,261	5,684	6,048
31	216	5,338	5,774	6,138
30	223	5,421	5,858	6,234
29	231	5,509	5,954	6,336
28	239	5,603	6,057	6,447
27	248	5,705	6,167	6,565
26	258	5,814	6,286	6,694
25	268	5,933	6,413	6,825
24	279	6,061	6,553	6,979
23	291	6,220	6,703	7,142
22	305	6,352	6,868	7,318
21	319	6,517	7,049	7,512

[a] Refers to DS/SD flow path data sets and calculations: 1 depot means total system throughput; 2 depots means total system throughput divided by 2; 3 depots means total system throughput divided by 3; etc.

COST CURVE SUMMARY

Flow path 10

Throughput volume level		Total annual cost (thousands of dollars)		
No. of depots[a]	Total annual throughput volume (1,000 hundredweight)	Region I	Region II	Region III
20	335	6,697	7,246	7,725
19	353	6,902	7,466	7,960
18	372	7,126	7,709	8,222
17	394	7,378	7,982	8,513
16	419	7,660	8,288	8,841
15	447	7,970	8,636	9,214
14	479	8,307	9,031	9,642
13	516	8,695	9,460	10,132
12	559	9,153	9,956	10,669
11	609	9,687	10,542	11,300
10	670	10,333	11,244	12,057
9	745	11,119	12,103	12,982
8	838	12,109	13,176	14,138
7	958	13,369	14,556	15,624
6	1,117	15,054	16,396	17,607
5	1,341	17,407	18,971	20,383
4	1,676	20,819	22,835	24,546
3	2,234	26,786	28,736	31,460
2	3,352	38,009	42,011	45,229
1	6,703	74,392	81,096	87,350

[a]Refers to DS/SD flow path data sets and calculations: 1 depot means total system throughput; 2 depots means total system throughput divided by 2; 3 depots means total system throughput divided by 3; etc.

COST CURVE SUMMARY

Flow path 11

Throughput volume level		Total annual cost (thousands of dollars)		
No. of depots[a]	Total annual throughput volume (1,000 hundredweight)	Region I	Region II	Region III
40	342	2,751	2,911	3,096
39	351	2,766	2,927	3,122
38	360	2,827	2,992	3,190
37	370	2,888	3,060	3,264
36	380	2,957	3,129	3,339
35	391	3,025	3,204	3,420
34	403	3,098	3,286	3,505
33	415	3,172	3,363	3,592
32	428	3,252	3,447	3,684
31	442	3,338	3,539	3,786
30	456	3,426	3,636	3,887
29	472	3,521	3,740	3,998
28	489	3,625	3,848	4,113
27	507	3,735	3,965	4,241
26	526	3,853	4,095	4,374
25	547	3,980	4,226	4,524
24	570	4,137	4,395	4,704
23	595	4,300	4,569	4,892
22	622	4,481	4,764	5,101
21	652	4,893	5,203	5,581

[a]Refers to DS/SD flow path data sets and calculations: 1 depot means total system throughput; 2 depots means total system throughput divided by 2; 3 depots means total system throughput divided by 3; etc.

COST CURVE SUMMARY

Flow path 11

Throughput volume level		Total annual cost (thousands of dollars)		
No. of depots[a]	Total annual throughput volume (1,000 hundredweight)	Region I	Region II	Region III
20	684	5,111	5,440	5,833
19	720	5,372	5,757	6,132
18	760	5,652	6,017	6,459
17	805	5,962	6,347	6,815
16	855	6,308	6,720	7,216
15	912	7,195	7,134	7,663
14	978	7,150	7,619	8,155
13	1,053	7,659	8,158	8,776
12	1,141	8,251	8,807	9,455
11	1,244	8,940	9,540	10,251
10	1,369	9,760	10,418	11,197
9	1,521	10,837	11,571	12,443
8	1,711	12,152	12,980	13,954
7	1,955	13,782	14,728	15,841
6	2,281	15,899	16,996	18,292
5	2,737	18,819	20,180	21,628
4	3,422	23,573	25,029	27,164
3	4,562	31,179	33,568	35,953
2	6,844	45,760	49,582	52,479
1	13,687	90,319	96,740	104,510

[a]Refers to DS/SD flow path data sets and calculations: 1 depot means total system throughput; 2 depots means total system throughput divided by 2; 3 depots means total system throughput divided by 3; etc.

EXHIBIT F

DEVELOPMENT OF WORKLOAD DATA

The first step in developing direct variable costs for a nominal depot at various levels of throughput is to construct a set of workload requirements for handling and storing materiel. The description of the process employed to construct the needed workload requirements is the subject of this Exhibit.

Important elements in the process are described in Schedule F-I and shown in flowchart form in Schedule F-II.

Schedules F-III, F-IV, F-V, and F-VI are sample pages from output reports of workload requirements used to develop nominal depot costs. These Schedules show total system active assets, inactive assets, daily shipments, and daily receipts, respectively. The sample pages are for Flow Paths Nos. 10 and 11. Similar data sets for the remaining nine flow paths were generated and used to calculate nominal costs.

Schedule F-I

Narrative

Seven steps were involved in the generation of workload requirements by flow path from the DODMDS Study Group data base. These steps were:

1. Submission of data requests.

2. Data processing to format data by Federal Supply Class (FSC).

3. Determination and application of allocation decision rules.

4. Data processing to format data by DODMDS product group.

5. Grouping of data sets by flow path.

6. Conversion of annual data values to a daily basis.

7. Calculation of data sets for various levels of throughput.

A more detailed description of each step follows:

1. Submission of data requests. Formal data requests, in the form of programming specifications, were submitted to the Study Group programmers. The programs specified were designed to extract inbound, outbound, and inventory data from the DODMDS data base and to structure these data into usable formats for nominal cost development. Three such requests were submitted, one each for shipments, receipts, and assets.

- Shipment data request. This specification was designed to divide the base year annual shipments into two groups (large and small NSN's) and to subdivide these groups by physical characteristics. Large NSN's, defined as having at least one dimension larger than four feet, were subdivided by dimensional ranges. Small NSN's, defined as having no dimension larger than four feet and thereby being palletizable, were subdivided by unit of issue cube ranges.

- Issues and units of issue shipped, average weights per unit of issue, and cube shipped were key data elements included in the output format. Issues in the small category were separated into equivalent pallets and nonpalletized issues using a conversion factor of 55 cubic feet per pallet.

- Receipt data request. Like shipments, base year annual receipts were requested to be separated into large and small

categories by NSN dimensions. A further subdivision by cubic feet per receipt was applied to each dimensional group. The number of receipts and total cube received was requested for each dimensional group and subdivision.

- Asset data request. Assets were also requested to be separated into the two categories by dimensional characteristics. The small category was further subdivided by inventory lot size. For each dimensional group and subdivision, the number of NSN's, total cubic feet in inventory, total unit packs, and total units of issue were the data elements requested.

The asset data request included two additional data formatting functions. First, the assets at existing depots were to be compared against shipments, by NSN, to develop separate output files for active and inactive assets. Active assets are defined as those NSN's which had at least one issue during the study base year. Inactive assets are those NSN's which had no issues during this period.

The second additional function requested was to separate assets by storage mode. Parameters within the Study Group data base were identified to allow this separation into four storage modes -- cold, hazardous, security, and all other.

2. Data processing to format data by Federal Supply Class (FSC). The asset and shipment data requests were first fulfilled using the data base structured by FSC. The resulting output reports showed shipments, inactive assets and active assets, formatted as described above, by FSC. Due to data unavailability, receipt data were not processed at this time.

FSC structured output reports were used to determine handling and storage parameters for later use. The most important use of these reports was the determination of allocation decision rules as described below.

3. Determination and application of allocation decision rules. Separation of NSN's into large and small categories by physical dimension was possible only for those NSN's having dimensional data in the data base. Those without available dimensional data were placed in a third category -- other. This third step was to develop rules for allocating NSN's in the "other" category to "large" and "small."

These rules were developed under the following planning assumption:

> Unless known to be otherwise (NSN's such as long lengths, sheets, etc.), all NSN's in the "other" category with a unit of issue cube less than or equal to 1.0 cubic feet were assumed to be small, and all NSN's in the "other" category with a unit of issue cube greater than 55 cubic feet were assumed to be large.

Rules for allocating NSN's still remaining in the "other" category were developed by inspection of output reports by FSC, and using descriptive information from the DOD Cataloging Handbook (H2-1), Federal Supply Classification-Part 1, Groups and Classes.

Allocation rules were developed for each FSC and then combined to obtain rules for DODMDS product groups. Rules for each product group were applied to the output data received from the Study Group to obtain allocated data sets for shipments, receipts, and assets.

4. Data processing to format data by DODMDS product group. The data requests were also fulfilled using the data base developed by the Study Group structured by product group. Shipment, receipt, and asset data requests were fulfilled at this time. Shipments and assets were processed together to obtain active and inactive asset data, as well as similar formats for both shipments and assets. In this way, shipments were subdivided by asset lot size and storage mode, as well as those subdivisions mentioned above.

5. Grouping of data sets by flow path. At this stage in the requirements development process, allocated data sets for active assets, inactive assets, annual shipments and annual receipts were fully developed by DODMDS product group and storage mode. To transform these data into flow path specific sets, the following flow path parameters or consolidation rules were applied:

Flow paths		Corresponding DODMDS product groups
Number	Description	
1	Cold storage items	All items in cold storage mode
2	Hazardous storage items	All items in hazardous storage mode
3	Security storage items	All items in security storage mode
4	Small arms	Product Group 101
5	Ships, boats, aircraft, railway equipment	Product Groups 151, 152, 191, 221
6	Aircraft engines	Product Group 162
7	Vehicles	Product Groups 231, 232, 241
8	Tires	Product Groups 264, 265
9	Subsistence	Product Groups 894, 895
10	Other large	All other product groups -- large data category
11	Other small	All other product groups -- small data category

6. Conversion of annual data values to a daily basis. Since daily workload requirements are needed to develop nominal depot costs, annual shipment and receipt data sets were converted to a daily basis. Receipts were converted by dividing annual values by 251, the number of working days per year.

Conversion of shipments from annual to daily volumes involved a different routine. The annual shipment data received from the Study Group were overstated as they included shipments from depots not included in the DODMDS study. These nonstudy depot data were factored out during the annual-to-daily conversion process. Divisors other than 251 were developed for each flow path based on the estimate of nonstudy depot data included in each. The percentage of nonstudy depot data and the conversion divisors used are shown below.

Flow path number	Percentage of nonstudy depot data[a]	Conversion divisor used[b]
1	4.08	261
2	4.08	261
3	4.08	261
4	15.70	290
5	15.38	290
6	4.65	263
7	1.54	255
8	12.87	283
9	25.47	315
10	4.08	261
11	4.08	261

[a]Estimate from Study Group, 13 April 1977, based on DODMDS Report A1.78.

[b]251 working days per year x (1 + nonstudy percentage).

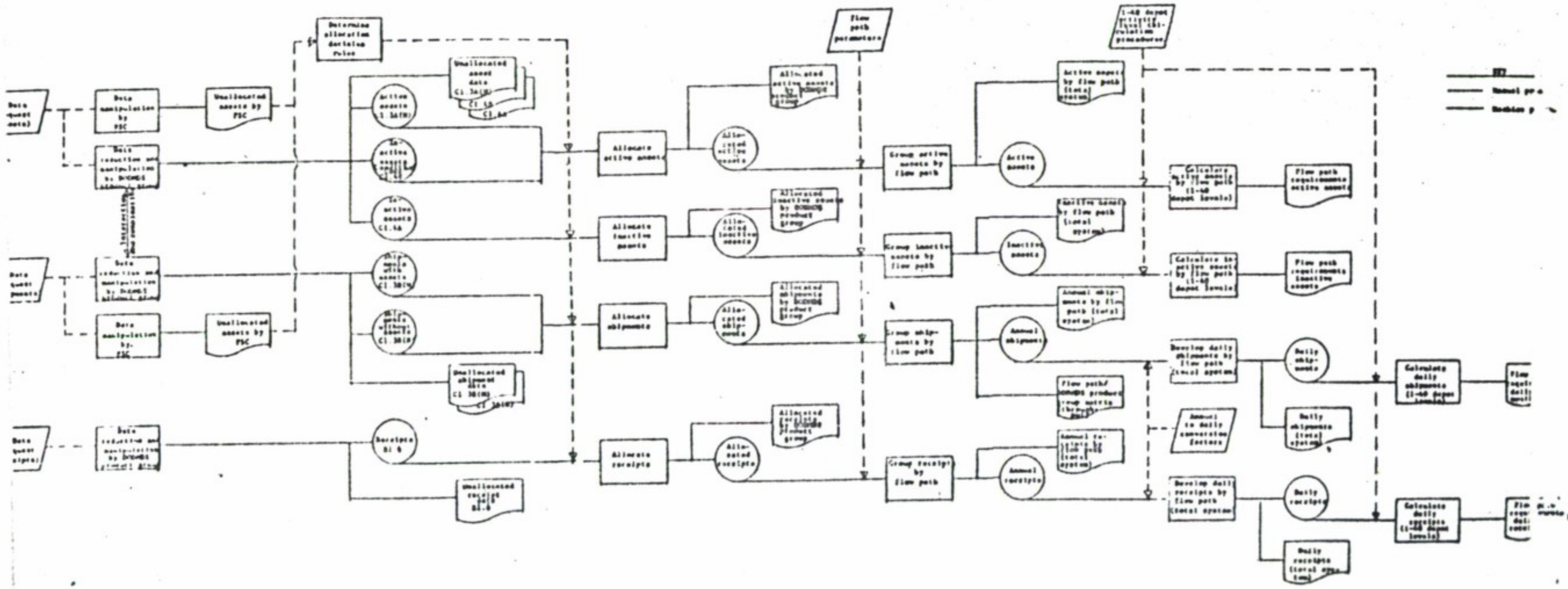
7. Calculation of data sets for various levels of throughput. To develop nominal depot costs at various levels of throughput, the total system data sets had to be manipulated by a final set of calculation procedures. Total system daily shipments, daily receipts, and assets by flow path were each divided by 2, 3, ... 40. The resulting data sets represent workload requirements considering that the materiel in each flow path is housed in two locations, three locations, ... 40 locations.

In addition to dividing total system requirements by 2-40, inventory lot sizes were reduced systematically to reflect spreading a fixed total system inventory over 2-40 locations.

Four data sets representing workload requirements by flow path resulted from the development described above.

- Daily shipments at 40 levels of throughput.
- Daily receipts at 40 levels of throughput.
- Active assets corresponding to 40 levels of throughput.
- Inactive assets corresponding to 40 levels of throughput.

These four data sets represent the storage and handling requirements used to develop nominal depot direct variable costs.



Schedule F-II

Development of Flow Path Requirements

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Schedule F-III

Sample Data -- Active Assets -- Total System

FLOW PATH = 10
LARGE DIMENSION
CATALOG DATA

LONGEST DIMENSION	2D LONGEST DIMENSION	THIRD DIMENSION	TOTAL NSNS	TOTAL CUBIC FEET	TOTAL NO. UNIT PACKS	NUMBER OF UNITS OF ISSUE
GT 20,	GT 8,	GT 6,	2904,	9659777.87	153513,	179620,
GT 20,	GT 8,	LTE 6,	553,	3393089.72	700880,	713064,
GT 20,	LTE 8,	LTE 8,	786,	6220386.50	94840,	94576,
		SUBTOTAL=	4243,	19303254.09	910639,	987262,
GT 68 LTE 20,	GT 68 LTE 20,	GT 66 LTE 20,	47,	604172.52	477,	487,
GT 68 LTE 20,	GT 68 LTE 20,	LTE 6,	263,	2324255.51	3060,	3131,
GT 68 LTE 20,	GT 48 LTE 8,	GT 46 LTE 6,	643,	5569477.74	11248,	11262,
GT 68 LTE 20,	GT 48 LTE 8,	LTE 4,	555,	1902731.15	4508,	4520,
GT 68 LTE 20,	GT 16 LTE 4,	GT 16 LTE 4,	1069,	[illegible].63	26081,	26960,
GT 68 LTE 20,	GT 16 LTE 4,	LTE 1,	604,	691962.70	13022,	13130,
GT 68 LTE 20,	LTE 1,	LTE 1,	6165,	7166924.51	12032402,	12649281,
		SUBTOTAL=	9436,	22773190.77	12147748,	12715771,
GT 48 LTE 8,	GT 48 LTE 8,	GT 48 LTE 8,	636,	3067417.60	10154,	10252,
GT 48 LTE 8,	GT 48 LTE 8,	LTE 4,	4470,	6255060.99	6100412,	6452398,
GT 48 LTE 8,	GT 16 LTE 4,	GT 16 LTE 4,	4336,	6701937.57	115104,	117048,
GT 48 LTE 8,	GT 16 LTE 4,	LTE 1,	3249,	11242582.29	90552,	90113,
GT 48 LTE 8,	LTE 1,	LTE 1,	3404,	13204914.64	193692,	199619,
		SUBTOTAL=	16177,	44491433.29	6503994,	6863430,
LARGE DIMENSION GR/COM TOTAL=			29856,	85567877.15	19564431,	20546463,

FLOW PATH = 11
SMALL DIMENSION
CATALOG DATA

UNIT OF ISSUE CUBE IN CUBIC FEET	MEAN CUBE	TOTAL DOD INVENTORY -- INVENTORY CUBE PER NSN IN CUBIC FEET	NSNS IN CUBE	TOTAL CUBIC FEET	TOTAL NO. UNIT PACKS	NUMBER OF UNITS OF ISSUE
LTE 1,0		LTE 1,0	559646,	182021,63	12096047,	13252312,
LTE 1,0		GT 1,0+LTE 8,0	467848,	1483011,95	64737819,	82702655,
LTE 1,0		GT 8,0+LTE 14,0	146353,	1526278,06	52138248,	77383566,
LTE 1,0		GT 18,0+LTE 55,0	110471,	3461932,88	95220040,	165864118,
LTE 1,0		GT 55,0+LTE 110,0	39396,	3048411,11	71633966,	143134278,
LTE 1,0		GT 110,0+LTE 275,0	29432,	5031034,00	102758585,	225129112,
LTE 1,0		GT 275,0+LTE 550,0	11600,	4452628,15	88810742,	168246132,
LTE 1,0		GT 550,0+LTE 1375,0	7737,	6539121,30	110163461,	248350585,
LTE 1,0		GT 1375,0+LTE 2750,0	2652,	5086614,04	75637232,	163461168,
LTE 1,0		GT 2750,0+LTE 4125,0	917,	3077033,00	47246749,	81908889,
LTE 1,0		GT 4125,0+LTE 5500,0	434,	2065904,68	36982234,	65453690,
LTE 1,0		GT 5500,0	1315,	36408997,03	602200880,	796579341,
LTE 1,0	53,29	SUBTOTAL=	1357801,	72362887,83	1355220663,	2257465640,
GT 1,0 AND LTE 8,0		LTE 1,0	0,	0,0	0,	0,
GT 1,0 AND LTE 8,0		GT 1,0+LTE 8,0	15081,	61088,16	31376,	31410,
GT 1,0 AND LTE 8,0		GT 8,0+LTE 14,0	9006,	114754,90	57666,	57791,
GT 1,0 AND LTE 8,0		GT 18,0+LTE 55,0	13078,	457106,87	210799,	211463,
GT 1,0 AND LTE 8,0		GT 55,0+LTE 110,0	6640,	527235,18	246667,	247176,
GT 1,0 AND LTE 8,0		GT 110,0+LTE 275,0	6230,	1104074,31	487716,	491347,
GT 1,0 AND LTE 8,0		GT 275,0+LTE 550,0	2907,	1152846,29	497289,	501476,
GT 1,0 AND LTE 8,0		GT 550,0+LTE 1375,0	2060,	1409640,20	761563,	774457,
GT 1,0 AND LTE 4,0		GT 1375,0+LTE 2750,0	872,	1726973,20	694133,	712695,
GT 1,0 AND LTE 8,0		GT 2750,0+LTE 4125,0	294,	997536,50	405679,	415070,
GT 1,0 AND LTE 6,0		GT 4125,0+LTE 5500,0	172,	830090,55	323451,	336294,
GT 1,0 AND LTE 4,0		GT 5500,0	511,	28939499,35	14192412,	14511026,
GT 1,0 AND LTE 8,0	663,18	SUBTOTAL=	56847,	37699547,53	17907943,	18293024,
GT 8,0 AND LTE 18,0		LTE 1,0	0,	0,0	0,	0,
GT 8,0 AND LTE 18,0		GT 1,0+LTE 8,0	0,	0,0	0,	0,
GT 8,0 AND LTE 18,0		GT 8,0+LTE 18,0	1389,	17688,42	1545,	1548,
GT 8,0 AND LTE 18,0		GT 18,0+LTE 55,0	1590,	56599,66	5043,	5050,
GT 8,0 AND LTE 18,0		GT 55,0+LTE 110,0	1058,	87340,69	7551,	7563,
GT 8,0 AND LTE 18,0		GT 110,0+LTE 275,0	1189,	221802,25	18853,	18902,
GT 8,0 AND LTE 18,0		GT 275,0+LTE 550,0	767,	308965,04	26420,	26457,
GT 8,0 AND LTE 18,0		GT 550,0+LTE 1375,0	660,	607865,43	50507,	50669,
GT 8,0 AND LTE 18,0		GT 1375,0+LTE 2750,0	275,	562435,99	46029,	46961,
GT 8,0 AND LTE 18,0		GT 2750,0+LTE 4125,0	105,	359739,21	30621,	30740,
GT 8,0 AND LTE 18,0		GT 4125,0+LTE 5500,0	52,	261391,29	20299,	20303,
GT 8,0 AND LTE 18,0		GT 5500,0	216,	9277672,48	758814,	781159,
GT 8,0 AND LTE 18,0	[illegible]	SUBTOTAL=	7301,	11761498,46	945082,	969372,

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GT 18.0 AND LTE 55.0		LTE 1.0	0.	0.0	0.	0.
GT 18.0 AND LTE 55.0		GT 1.0+LTE 8.0	0.	0.0	0.	0.
GT 18.0 AND LTE 55.0		GT 8.0+LTE 18.0	0.	0.0	0.	0.
GT 18.0 AND LTE 55.0		GT 18.0+LTE 55.0	426.	31874.08	1149.	1149.
GT 18.0 AND LTE 55.0		GT 55.0+LTE 110.0	549.	49612.66	1769.	1775.
GT 18.0 AND LTE 55.0		GT 110.0+LTE 275.0	712.	146756.23	5126.	5129.
GT 18.0 AND LTE 55.0		GT 275.0+LTE 550.0	695.	219173.55	7610.	7619.
GT 18.0 AND LTE 55.0		GT 550.0+LTE 1375.0	484.	478482.32	15830.	15854.
GT 18.0 AND LTE 55.0		GT 1375.0+LTE 2750.0	435.	515459.60	16671.	17063.
GT 18.0 AND LTE 55.0		GT 2750.0+LTE 4125.0	105.	393752.84	12646.	12703.
GT 18.0 AND LTE 55.0		GT 4125.0+LTE 5500.0	64.	337634.39	11026.	11160.
GT 18.0 AND LTE 55.0		GT 5500.0	214.	8902964.12	281466.	286920.
GT 18.0 AND LTE 55.0	3005.62	SUBTOTAL=	3686.	11072709.79	353468.	359317.
GT 55.0		LTE 1.0	0.	0.0	0.	0.
GT 55.0		GT 1.0+LTE 8.0	0.	0.0	0.	0.
GT 55.0		GT 8.0+LTE 18.0	0.	0.0	0.	0.
GT 55.0		GT 18.0+LTE 55.0	0.	0.0	0.	0.
GT 55.0		GT 55.0+LTE 110.0	0.	0.0	0.	0.
GT 55.0		GT 110.0+LTE 275.0	0.	0.0	0.	0.
GT 55.0		GT 275.0+LTE 550.0	0.	0.0	0.	0.
GT 55.0		GT 550.0+LTE 1375.0	0.	0.0	0.	0.
GT 55.0		GT 1375.0+LTE 2750.0	0.	0.0	0.	0.
GT 55.0		GT 2750.0+LTE 4125.0	0.	0.0	0.	0.
GT 55.0		GT 4125.0+LTE 5500.0	0.	0.0	0.	0.
GT 55.0		GT 5500.0	0.	0.0	0.	0.
GT 55.0	0.0	SUBTOTAL=	0.	0.0	0.	0.
	SMALL DIMENSION SH/COM	TOTAL=	1469658.	132896643.61	1374407756.	4477107643.

Schedule F-IV

Sample Data -- Inactive Assets -- Total System

FLOW PATH = 10
LARGE DIMENSION
CATALOG DATA

LONGEST DIMENSION	2D LONGEST DIMENSION	THIRD DIMENSION	TOTAL NSNS	TOTAL CUBIC FEET	TOTAL NO. UNIT PACKS	NUMBER OF UNITS OF ISSUE
GT 20,	GT 8,	GT 8,	2040,	12475243,87	97861,	93379,
GT 20,	GT 8,	LTE 8,	819,	1524047,87	26509,	26648,
GT 20,	LTE 8,	LTE 8,	995,	2258553,48	18525,	19828,
		SUBTOTAL=	3854,	16257845,22	142895,	139855,
GT 8& LTE 20,	GT 8& LTE 20,	GT 8& LTE 20,	43,	177012,22	1543,	1541,
GT 8& LTE 20,	GT 8& LTE 20,	LTE 8,	243,	1025966,53	10944,	11000,
GT 8& LTE 20,	GT 4& LTE 8,	GT 4& LTE 8,	269,	911338,86	27115,	27114,
GT 8& LTE 20,	GT 4& LTE 8,	LTE 4,	771,	13578577,16	35197,	35307,
GT 8& LTE 20,	GT 1& LTE 4,	GT 1& LTE 4,	962,	1500190,29	16334,	18219,
GT 8& LTE 20,	GT 1& LTE 4,	LTE 1,	862,	422045,19	10138,	11600,
GT 8& LTE 20,	LTE 1,	LTE 1,	3190,	3961083,53	761272,	785238,
		SUBTOTAL=	6300,	21516521,78	864533,	890019,
GT 4& LTE 8,	GT 4& LTE 8,	GT 4& LTE 8,	441,	40404496,96	44816,	44824,
GT 4& LTE 8,	GT 4& LTE 8,	LTE 4,	2704,	2742973,26	471799,	478590,
GT 4& LTE 8,	GT 1& LTE 4,	GT 1& LTE 4,	3878,	12265444,63	154121,	151855,
GT 4& LTE 8,	GT 1& LTE 4,	LTE 1,	3520,	8907770,55	53975,	74159,
GT 4& LTE 8,	LTE 1,	LTE 1,	4962,	80123845,10	150229,	218058,
		SUBTOTAL=	15505,	152484530,72	874942,	967436,
LARGE DIMENSION SN/CUN TOTAL=			25739,	210318897,72	1882370,	1997310,

FLOW PATH = 11
SMALL DIMENSION
CATALOG DATA

UNIT OF ISSUE CUBE IN CUBIC FEET	MEAN CUBE	TOTAL ODD INVENTORY INVENTORY CUBE PER NSN IN CUBIC FEET	NSNS IN CUBE	TOTAL CUBIC FEET	TOTAL NO. UNIT PACKS	NUMBER OF UNITS OF ISSUE
LTE 1.0		LTE 1.0	849176.	213560.50	10681546.	12320528.
LTE 1.0		GT 1.0+LTE 8.0	302336.	871748.39	21440343.	30887135.
LTE 1.0		GT 8.0+LTE 18.0	49533.	568466.09	10520528.	18237035.
LTE 1.0		GT 18.0+LTE 55.0	32836.	999004.28	14359783.	26698758.
LTE 1.0		GT 55.0+LTE 110.0	8649.	667309.27	6265207.	15862439.
LTE 1.0		GT 110.0+LTE 275.0	5485.	933823.34	10231455.	18324625.
LTE 1.0		GT 275.0+LTE 550.0	1624.	619692.47	6646271.	11548750.
LTE 1.0		GT 550.0+LTE 1375.0	848.	705003.86	9805395.	13699080.
LTE 1.0		GT 1375.0+LTE 2750.0	238.	463292.38	8017616.	9399534.
LTE 1.0		GT 2750.0+LTE 4125.0	69.	229654.86	3853542.	4278877.
LTE 1.0		GT 4125.0+LTE 5500.0	40.	190657.53	3032991.	3634433.
LTE 1.0		GT 5500.0	143.	28291250.23	164284813.	167182007.
LTE 1.0	27.50	SUBTOTAL=	1250977.	34773463.13	271339488.	332081201.
GT 1.0 AND LTE 8.0		LTE 1.0	0.	0.0	0.	0.
GT 1.0 AND LTE 8.0		GT 1.0+LTE 8.0	19282.	76788.03	36217.	36263.
GT 1.0 AND LTE 8.0		GT 8.0+LTE 18.0	8490.	106234.65	43447.	43532.
GT 1.0 AND LTE 8.0		GT 18.0+LTE 55.0	7624.	245381.97	94078.	94499.
GT 1.0 AND LTE 8.0		GT 55.0+LTE 110.0	2411.	192319.24	69676.	70066.
GT 1.0 AND LTE 8.0		GT 110.0+LTE 275.0	1589.	282355.47	97536.	98060.
GT 1.0 AND LTE 8.0		GT 275.0+LTE 550.0	681.	287364.13	86237.	87613.
GT 1.0 AND LTE 8.0		GT 550.0+LTE 1375.0	425.	378892.36	115411.	117327.
GT 1.0 AND LTE 8.0		GT 1375.0+LTE 2750.0	145.	291244.82	100625.	105303.
GT 1.0 AND LTE 8.0		GT 2750.0+LTE 4125.0	58.	197660.38	82736.	84169.
GT 1.0 AND LTE 8.0		GT 4125.0+LTE 5500.0	32.	162259.45	42276.	45868.
GT 1.0 AND LTE 8.0		GT 5500.0	80.	1708707.67	391388.	424085.
GT 1.0 AND LTE 8.0	96.17	SUBTOTAL=	40817.	3925204.97	1159627.	1206807.
GT 8.0 AND LTE 18.0		LTE 1.0	0.	0.0	0.	0.
GT 8.0 AND LTE 18.0		GT 1.0+LTE 8.0	0.	0.0	0.	0.
GT 8.0 AND LTE 18.0		GT 8.0+LTE 18.0	1698.	24210.09	2087.	2087.
GT 8.0 AND LTE 18.0		GT 18.0+LTE 55.0	1700.	57847.92	4983.	4987.
GT 8.0 AND LTE 18.0		GT 55.0+LTE 110.0	678.	55696.03	4694.	4695.
GT 8.0 AND LTE 18.0		GT 110.0+LTE 275.0	491.	89822.10	7255.	7260.
GT 8.0 AND LTE 18.0		GT 275.0+LTE 550.0	210.	85595.72	6701.	6722.
GT 8.0 AND LTE 18.0		GT 550.0+LTE 1375.0	133.	120206.57	9355.	9370.
GT 8.0 AND LTE 18.0		GT 1375.0+LTE 2750.0	36.	74295.64	5975.	5975.
GT 8.0 AND LTE 18.0		GT 2750.0+LTE 4125.0	12.	42689.01	3368.	3368.
GT 8.0 AND LTE 18.0		GT 4125.0+LTE 5500.0	5.	24477.60	1936.	1938.
GT 8.0 AND LTE 18.0		GT 5500.0	22.	52692147.10	4427582.	4439261.
GT 8.0 AND LTE 18.0	10311.56	SUBTOTAL=	5185.	53466947.78	4473938.	4485665.

GT 18.0 AND LTE 55.0		LTE 1.0	0.	0.0	0.	0.
GT 18.0 AND LTE 55.0		GT 1.0+LTE 8.0	0.	0.0	0.	0.
GT 18.0 AND LTE 55.0		GT 8.0+LTE 18.0	0.	0.0	0.	0.
GT 18.0 AND LTE 55.0		GT 18.0+LTE 55.0	1095.	40708.24	1419.	1422.
GT 18.0 AND LTE 55.0		GT 55.0+LTE 110.0	413.	43279.48	1481.	1487.
GT 18.0 AND LTE 55.0		GT 110.0+LTE 275.0	390.	80834.55	2617.	2639.
GT 18.0 AND LTE 55.0		GT 275.0+LTE 550.0	216.	102653.78	3228.	3262.
GT 18.0 AND LTE 55.0		GT 550.0+LTE 1375.0	139.	150690.27	4306.	4380.
GT 18.0 AND LTE 55.0		GT 1375.0+LTE 2750.0	39.	95181.00	4969.	2917.
GT 18.0 AND LTE 55.0		GT 2750.0+LTE 4125.0	14.	72175.14	1898.	1935.
GT 18.0 AND LTE 55.0		GT 4125.0+LTE 5500.0	8.	43953.13	1085.	1085.
GT 18.0 AND LTE 55.0		GT 5500.0	25.	671802.12	14295.	19478.
GT 18.0 AND LTE 55.0	542.48	SUBTOTAL=	2399.	1301277.71	34193.	38605.
GT 55.0		LTE 1.0	0.	0.0	0.	0.
GT 55.0		GT 1.0+LTE 8.0	0.	0.0	0.	0.
GT 55.0		GT 8.0+LTE 18.0	0.	0.0	0.	0.
GT 55.0		GT 18.0+LTE 55.0	0.	0.0	0.	0.
GT 55.0		GT 55.0+LTE 110.0	0.	0.0	0.	0.
GT 55.0		GT 110.0+LTE 275.0	0.	0.0	0.	0.
GT 55.0		GT 275.0+LTE 550.0	0.	0.0	0.	0.
GT 55.0		GT 550.0+LTE 1375.0	0.	0.0	0.	0.
GT 55.0		GT 1375.0+LTE 2750.0	0.	0.0	0.	0.
GT 55.0		GT 2750.0+LTE 4125.0	0.	0.0	0.	0.
GT 55.0		GT 4125.0+LTE 5500.0	0.	0.0	0.	0.
GT 55.0		GT 5500.0	0.	0.0	0.	0.
GT 55.0	0.0	SUBTOTAL=	0.	0.0	0.	0.
		SMALL DIMENSION SH/COM TOTAL=	1299378.	93466937.59	277008286.	337812298.

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Schedule P-V

Sample Data -- Daily Shipments -- Total System

FLOW PATH = 11
LARGE DIMENSION

CATALOG DATA IN FEET LONGEST DIMENSION	2D LONGEST DIMENSION	THIRD DIMENSION		NUMBER OF ISSUES	AVERAGE WEIGHT PER UNIT OF ISSUE	NUMBER OF UNITS OF ISSUES SHIPPED	PALLET EQUIVALENTS UNITS OF ISSUE	PALLET EQUIVALENTS NUMBER OF PALLETS	NON-PALLETIZED TOTAL UNITS OF ISSUE	NON-PALLETIZED TOTAL CUBE
GT 20.	GT 8.	GT 8.		202.	0.58	531.	0.	0.	531.	24711.
GT 20.	GT 8.	LTE 8.		16.	58.05	78.	0.	0.	78.	14355.
GT 20.	LTE 8.	LTE 8.		59.	1.31	221.	0.	0.	221.	13906.
			SUBTOTAL=	277.	551.35	830.	0.	0.	830.	52972.
GT 08 LTE 20.	GT 08 LTE 20.	GT 08 LTE 20.		0.	994.30	10.	0.	0.	10.	6019.
GT 08 LTE 20.	GT 08 LTE 20.	LTE 8.		4.	113.84	19.	0.	0.	19.	3524.
GT 08 LTE 20.	GT 48 LTE 8.	GT 48 LTE 8.		15.	35.74	77.	0.	0.	77.	20353.
GT 08 LTE 20.	GT 48 LTE 8.	LTE 4.		16.	53.36	37.	0.	0.	37.	7583.
GT 08 LTE 20.	GT 18 LTE 4.	GT 18 LTE 4.		36.	11.22	84.	0.	0.	84.	9582.
GT 08 LTE 20.	GT 18 LTE 4.	LTE 1.		20.	7.68	54.	0.	0.	54.	3926.
GT 08 LTE 20.	LTE 1.	LTE 1.		741.	0.00	42914.	0.	0.	42914.	18254.
			SUBTOTAL=	832.	31.01	43195.	0.	0.	43195.	69221.
GT 48 LTE 8.	GT 48 LTE 8.	GT 48 LTE 8.		16.	20.34	78.	0.	0.	78.	16315.
GT 48 LTE 8.	GT 48 LTE 8.	LTE 4.		169.	0.01	5592.	0.	0.	5592.	28804.
GT 48 LTE 8.	GT 18 LTE 4.	GT 18 LTE 4.		130.	1.57	416.	0.	0.	416.	29680.
GT 48 LTE 8.	GT 18 LTE 4.	LTE 1.		100.	0.41	237.	0.	0.	237.	12911.
GT 48 LTE 8.	LTE 1.	LTE 1.		145.	0.12	493.	0.	0.	493.	25005.
			SUBTOTAL=	560.	128.18	6816.	0.	0.	6816.	112695.
			LARGE DIMENSION SM/CUM TOTAL=	1669.	52.53	50841.	0.	0.	50841.	234888.

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FLOW PATH = 11

SMALL DIMENSION UNIT OF ISSUE CUBE IN CUBIC FEET	INVENTORY CUBE PER NSN IN CUBIC FEET	NUMBER OF ISSUES	AVERAGE WEIGHT PER UNIT OF ISSUE	NUMBER OF UNITS OF ISSUE SHIPPED	PALLET EQUIVALENTS UNITS OF ISSUE	PALLET EQUIVALENTS NUMBER OF PALLETS	NON-PALLETIZED TOTAL UNITS OF ISSUE	NON-PALLETIZED TOTAL CUBE
LE 1	LE 1	14722.	0.00	164545.	3010.	5.	162036.	4835.
LE 1	GT 1&LE 8	23548.	0.00	317198.	18754.	37.	298920.	11061.
LE 1	GT 8&LE 18	11296.	0.00	206127.	4746.	10.	201663.	6568.
LE 1	GT 18&LE 55	14797.	0.00	422638.	25182.	22.	396971.	11787.
LE 1	GT 55&LE 110	8273.	0.00	351135.	7942.	19.	342636.	9364.
LE 1	GT 110&LE 275	9142.	0.00	589503.	12415.	45.	576976.	15583.
LE 1	GT 275&LE 550	5500.	0.00	525601.	41339.	50.	479526.	13494.
LE 1	GT 550&LE 1375	4837.	0.00	686791.	44680.	67.	643058.	18782.
LE 1	GT 1375&LE 2750	2347.	0.00	399352.	19171.	42.	380597.	12341.
LE 1	GT 2750&LE 4125	980.	0.00	245266.	56370.	80.	189916.	6844.
LE 1	GT 4125&LE 5500	641.	0.00	191212.	43157.	28.	147367.	5177.
LE 1	GT 5500	2006.	0.00	821627.	197032.	293.	626331.	27812.
LE 1	SUBTOTAL=	98089.	0.56	4920995.	474998.	696.	4445947.	143688.
GT 1&LE 8	LE 1	0.	0.0	0.	0.	0.	0.	0.
GT 1&LE 8	GT 1&LE 8	614.	0.03	1670.	256.	10.	1459.	2962.
GT 1&LE 8	GT 8&LE 18	409.	0.04	1030.	203.	12.	832.	1969.
GT 1&LE 8	GT 18&LE 55	711.	48.01	1780.	257.	15.	1542.	3704.
GT 1&LE 8	GT 55&LE 110	497.	42.29	1622.	364.	19.	1252.	2933.
GT 1&LE 8	GT 110&LE 275	679.	42.67	2470.	309.	15.	2124.	5095.
GT 1&LE 8	GT 275&LE 550	472.	42.78	1922.	346.	20.	1565.	3881.
GT 1&LE 8	GT 550&LE 1375	476.	51.49	2353.	495.	28.	1824.	4435.
GT 1&LE 8	GT 1375&LE 2750	290.	47.26	2671.	969.	40.	1651.	3743.
GT 1&LE 8	GT 2750&LE 4125	100.	43.12	1246.	471.	24.	730.	1604.
GT 1&LE 8	GT 4125&LE 5500	95.	55.63	1227.	544.	23.	653.	1414.
GT 1&LE 8	GT 5500	353.	53.83	14637.	11429.	663.	3352.	7684.
GT 1&LE 8	SUBTOTAL=	4702.	49.69	32628.	15649.	869.	16964.	39429.
GT 8&LE 18	LE 1	0.	0.0	0.	0.	0.	0.	0.
GT 8&LE 18	GT 1&LE 8	0.	0.0	0.	0.	0.	0.	0.
GT 8&LE 18	GT 8&LE 18	43.	221.40	136.	73.	18.	64.	740.
GT 8&LE 18	GT 18&LE 55	46.	214.88	86.	17.	4.	70.	777.
GT 8&LE 18	GT 55&LE 110	44.	159.39	140.	71.	18.	72.	789.
GT 8&LE 18	GT 110&LE 275	65.	234.62	174.	82.	20.	97.	1136.
GT 8&LE 18	GT 275&LE 550	58.	243.73	132.	38.	9.	98.	1080.
GT 8&LE 18	GT 550&LE 1375	79.	227.86	215.	132.	31.	141.	1604.
GT 8&LE 18	GT 1375&LE 2750	35.	225.79	129.	74.	18.	56.	629.
GT 8&LE 18	GT 2750&LE 4125	20.	136.27	127.	67.	20.	41.	451.
GT 8&LE 18	GT 4125&LE 5500	14.	115.70	91.	67.	15.	24.	295.
GT 8&LE 18	GT 5500	119.	227.95	1415.	1275.	298.	149.	2198.
GT 8&LE 18	SUBTOTAL=	523.	223.43	2765.	1916.	451.	862.	4699.

GT 18&LE 55	LE 1	0.	0.0	0.	0.	0.	0.	0.
GT 18&LE 55	GT 1&LE 8	0.	0.0	0.	0.	0.	0.	0.
GT 18&LE 55	GT 8&LE 18	0.	0.0	0.	0.	0.	0.	0.
GT 18&LE 55	GT 18&LE 55	26.	452.34	70.	58.	45.	17.	386.
GT 18&LE 55	GT 55&LE 110	20.	437.84	45.	40.	35.	10.	251.
GT 18&LE 55	GT 110&LE 275	26.	470.64	68.	60.	48.	13.	310.
GT 18&LE 55	GT 275&LE 550	30.	406.99	75.	60.	48.	18.	442.
GT 18&LE 55	GT 550&LE 1375	30.	576.99	72.	59.	47.	18.	471.
GT 18&LE 55	GT 1375&LE 2750	15.	566.39	46.	40.	31.	8.	201.
GT 18&LE 55	GT 2750&LE 4125	12.	525.52	37.	35.	25.	5.	137.
GT 18&LE 55	GT 4125&LE 5500	6.	598.96	19.	17.	12.	3.	77.
GT 18&LE 55	GT 5500	62.	571.09	389.	374.	322.	26.	707.
GT 18&LE 55	SUBTOTAL*	227.	529.14	821.	743.	613.	118.	2982.
GT 55	LE 1	0.	0.0	0.	0.	0.	0.	0.
GT 55	GT 1&LE 8	0.	0.0	0.	0.	0.	0.	0.
GT 55	GT 8&LE 18	0.	0.0	0.	0.	0.	0.	0.
GT 55	GT 18&LE 55	0.	0.0	0.	0.	0.	0.	0.
GT 55	GT 55&LE 110	0.	0.0	0.	0.	0.	0.	0.
GT 55	GT 110&LE 275	0.	0.0	0.	0.	0.	0.	0.
GT 55	GT 275&LE 550	0.	0.0	0.	0.	0.	0.	0.
GT 55	GT 550&LE 1375	0.	0.0	0.	0.	0.	0.	0.
GT 55	GT 1375&LE 2750	0.	900.00	0.	0.	0.	0.	18.
GT 55	GT 2750&LE 4125	0.	0.0	0.	0.	0.	0.	0.
GT 55	GT 4125&LE 5500	0.	0.0	0.	0.	0.	0.	0.
GT 55	GT 5500	0.	660.00	5.	0.	0.	5.	292.
GT 55	SUBTOTAL*	0.	693.36	5.	0.	0.	5.	310.
SMALL DIMENSION SM/CUM TOTAL*		1035[illegible]	1.10	4457214.	493306.	2631.	4463966.	140108.

Schedule F-VI

Sample Data -- Daily Receipts -- Total System

FLOW PATH = 10
LARGE DIMENSION
CATALOG DATA IN FEET

LONGEST	2ND LONGEST	3RD LONGEST	PROCUREMENT DATA CUBE PER RECEIPT IN CUBIC FEET	NUMBER OF RECEIPTS	TOTAL CUBIC FEET
GT 40	GT 8	GT 8	LTE 1.0	40.	13.88
GT 40	GT 8	GT 8	GT 1.0 LTE 8.0	114.	488.88
GT 20	GT 8	GT 8	GT 8.0 LTE 18.0	57.	883.89
GT 20	GT 8	GT 8	GT 18.0 LTE 55.0	24.	894.32
GT 20	GT 8	GT 8	GT 55.0	65.	82128.05
GT 20	GT 8	LTE 8	LTE 1.0	1.	0.88
GT 20	GT 8	LTE 8	GT 1.0 LTE 8.0	1.	0.15
GT 40	GT 8	LTE 8	GT 8.0 LTE 18.0	0.	1.37
GT 20	GT 8	LTE 8	GT 18.0 LTE 55.0	0.	4.07
GT 20	GT 8	LTE 8	GT 55	1.	4182.88
GT 20	LTE 8	LTE 8	LTE 1.0	7.	5.91
GT 20	LTE 8	LTE 8	GT 1.0 LTE 8.0	17.	39.88
GT 20	LTE 8	LTE 8	GT 8.0 LTE 18.0	8.	38.78
GT 20	LTE 8	LTE 8	GT 18.0 LTE 55.0	4.	178.48
GT 20	LTE 8	LTE 8	GT 55.0	881	11888.88
			SUB TOTAL	888.	88988.18
GT 8 & LTE 20,	GT 8 & LTE 40,	GT 4 & LTE 20,	LTE 1.0	0.	0.01
GT 8 & LTE 20,	GT 8 & LTE 40,	GT 4 & LTE 20,	GT 1.0 LTE 8.0	0.	0.18
GT 8 & LTE 20,	GT 8 & LTE 20,	GT 8 & LTE 20,	GT 8.0 LTE 18.0	0.	0.18
GT 8 & LTE 20,	GT 8 & LTE 40,	GT 4 & LTE 20,	GT 18.0 LTE 55.0	0.	0.0
GT 8 & LTE 20,	GT 8 & LTE 20,	GT 8 & LTE 20,	GT 55.0	0.	483.98
GT 8 & LTE 20,	GT 8 & LTE 20,	LTE 4,	LTE 1.0	0.	0.18
GT 8 & LTE 20,	GT 8 & LTE 20,	LTE 8,	GT 1.0 LTE 8.0	0.	1.08
GT 8 & LTE 80,	GT 4 & LTE 40,	LTE 8,	GT 8.0 LTE 18.0	0.	1.08
GT 8 & LTE 40,	GT 8 & LTE 20,	LTE 8,	GT 18.0 LTE 55.0	0.	8.88
GT 8 & LTE 20,	GT 8 & LTE 20,	LTE 8,	GT 55.0	4.	12188.88
GT 8 & LTE 40,	GT 4 & LTE 8,	GT 4 & LTE 8,	LTE 1.0	2.	0.98
GT 8 & LTE 20,	GT 8 & LTE 8,	GT 4 & LTE 4,	GT 1.0 LTE 8.0	0.	1.02
GT 8 & LTE 20,	GT 4 & LTE 8,	GT 8 & LTE 8,	GT 8.0 LTE 18.0	0.	0.0
GT 8 & LTE 80,	GT 4 & LTE 8,	GT 8 & LTE 8,	GT 18.0 LTE 55.0	0.	4.07
GT 8 & LTE 20,	GT 4 & LTE 8,	GT 8 & LTE 8.	GT 55.0	22.	31148.88
GT 8 & LTE 20,	GT 4 & LTE 8,	LTE 4,	LTE 1.0	1.	0.02
GT 4 & LTE 20,	GT 4 & LTE 8,	LTE 4,	GT 1.0 LTE 8.0	0.	0.60
GT 8 & LTE 40,	GT 4 & LTE 8,	LTE 8,	GT 8.0 LTE 18.0	0.	2.05
GT 8 & LTE 20,	GT 4 & LTE 8,	LTE 4,	GT 18.0 LTE 55.0	1.	24.32
GT 8 & LTE 40,	GT 4 & LTE 8,	LTE 4,	GT 55.0	13.	14838.70
GT 8 & LTE 20,	GT 1 & LTE 4,	GT 1 & LTE 4,	LTE 1.0	3.	1.88
GT 8 & LTE 40,	GT 1 & LTE 4,	GT 1 & LTE 4,	GT 1.0 LTE 8.0	2.	5.07
GT 8 & LTE 60,	GT 1 & LTE 4,	GT 1 & LTE 4,	GT 8.0 LTE 18.0	1.	12.25
GT 8 & LTE 20,	GT 1 & LTE 4,	GT 1 & LTE 4	GT 18.0 LTE 55.0	12.	431.61
GT 8 & LTE 80,	GT 1 & LTE 4,	GT 1 & LTE 4.	GT 55.0	35.	14818.57
GT 8 & LTE 20,	GT 1 & LTE 4,	LTE 1,	LTE 1.0	1.	0.89
GT 8 & LTE 20,	GT 1 & LTE 4,	LTE 1,	GT 1.0 LTE 8.0	3.	11.36
GT 8 & LTE 20,	GT 1 & LTE 4,	LTE 1,	GT 8.0 LTE 18.0	6.	45.49
GT 8 & LTE 20,	GT 1 & LTE 4,	LTE 1,	GT 18.0 LTE 55.0	5.	140.91
GT 8 & LTE 80,	GT 1 & LTE 4,	LTE 1,	GT 55.0	8.	4400.43
GT 8 & LTE 20,	LTE 1,	LTE 1,	LTE 1.0	22.	11.83
GT 8 & LTE 20,	LTE 1,	LTE 1,	GT 1.0 LTE 8.0	48.	498.78
GT 8 & LTE 20,	LTE 1,	LTE 1,	GT 8.0 LTE 18.0	18.	458.38
GT 8 & LTE 60,	LTE 1,	LTE 1,	GT 18.0 LTE 58.0	13.	544.16
GT 8 & LTE 60,	LTE 1,	LTE 1,	GT 55.0	19.	80887.96
			SUB TOTAL	[illegible]	112065.05

5.177

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GT 4 & LTE 8,	GT 4 & LTE 8,	GT 4 & LTE 8,	LTE 1,0	1,	0,23
GT 4 & LTE 8,	GT 4 & LTE 8,	GT 4 & LTE 8,	GT 1,0 LTE 8,0	0,	0,83
GT 4 & LTE 8,	GT 4 & LTE 8,	GT 4 & LTE 8,	GT 8,0 LTE 18,0	0,	0,24
GT 4 & LTE 8,	GT 4 & LTE 8,	GT 4 & LTE 8,	GT 18,0 LTE 55,0	0,	6,41
GT 4 & LTE 8,	GT 4 & LTE 8,	GT 4 & LTE 8,	GT 55,0	37,	17462,53
GT 4 & LTE 8,	GT 4 & LTE 8,	LTE 4,	LTE 1,0	5,	2,97
GT 4 & LTE 8,	GT 4 & LTE 8,	LTE 4,	GT 1,0 LTE 8,0	8,	37,74
GT 4 & LTE 8,	GT 4 & LTE 8,	LTE 4,	GT 8,0 LTE 18,0	3,	81,61
GT 4 & LTE 8,	GT 4 & LTE 8,	LTE 4,	GT 18,0 LTE 55,0	11,	414,75
GT 4 & LTE 8,	GT 4 & LTE 8,	LTE 4,	GT 55,0	107,	65606,37
GT 4 & LTE 8,	GT 1 & LTE 4,	GT 1 & LTE 4,	LTE 1,0	10,	4,19
GT 4 & LTE 8,	GT 1 & LTE 4,	GT 1 & LTE 4,	GT 1,0 LTE 8,0	5,	36,01
GT 4 & LTE 8,	GT 1 & LTE 4,	GT 1 & LTE 4,	GT 8,0 LTE 18,0	19,	303,52
GT 4 & LTE 8,	GT 1 & LTE 4,	GT 1 & LTE 4,	GT 18,0 LTE 55,0	51,	1889,36
GT 4 & LTE 8,	GT 1 & LTE 4,	GT 1 & LTE 4,	GT 55,0	58,	30225,17
GT 4 & LTE 8,	GT 1 & LTE 4,	LTE 1,	LTE 1,0	3,	2,38
GT 4 & LTE 8,	GT 1 & LTE 4,	LTE 1,	GT 1,0 LTE 8,0	25,	194,62
GT 4 & LTE 8,	GT 1 & LTE 4,	LTE 1,	GT 8,0 LTE 18,0	22,	335,03
GT 4 & LTE 8,	GT 1 & LTE 4,	LTE 1,	GT 18,0 LTE 55,0	14,	470,40
GT 4 & LTE 8,	GT 1 & LTE 4,	LTE 1,	GT 55,0	9,	23781,24
GT 4 & LTE 8,	LTE 1,	LTE 1,	LTE 1,0	15,	10,29
GT 4 & LTE 8,	LTE 1,	LTE 1,	GT 1,0 LTE 8,0	44,	168,87
GT 4 & LTE 8,	LTE 1,	LTE 1,	GT 8,0 LTE 18,0	6,	146,40
GT 4 & LTE 8,	LTE 1,	LTE 1,	GT 18,0 LTE 55,0	6,	651,56
GT 4 & LTE 8,	LTE 1,	LTE 1,	GT 55,0	8,	14656,90
			SUB TOTAL	466,	180449,68
			FLOW PATHS TO LARGE DIMENSION -- TOTAL	1082,	352820,15

FLOW PATH = 11
SMALL DIMENSION
*CATALOG DATA IN FEET
UNIT OF ISSUE IN
CUBIC FEET

*PROCUREMENT DATA
CUBE PER RECEIPT
IN CUBIC FEET

CATALOG DATA (CUBIC FEET)	PROCUREMENT DATA (CUBIC FEET)		NUMBER OF RECEIPTS	TOTAL CUBIC FEET
LTE 1.0	LTE	1.0	12290.	3396.02
LTE 1.0	GT 1.0+LTE	8.0	3489.	10110.66
LTE 1.0	GT 8.0+LTE	18.0	746.	8895.53
LTE 1.0	GT 18.0+LTE	55.0	643.	19859.76
LTE 1.0	GT 55.0		512.	134282.93
		SUB TOTAL	17680.	176545.
GT 1.0 AND LTE 8.0	LTE	1.0	0.	0.0
GT 1.0 AND LTE 8.0	GT 1.0+LTE	8.0	1957.	6043.65
GT 1.0 AND LTE 8.0	GT 8.0+LTE	18.0	225.	2479.81
GT 1.0 AND LTE 8.0	GT 18.0+LTE	55.0	140.	4013.77
GT 1.0 AND LTE 8.0	GT 55.0		103.	50361.53
		SUB TOTAL	2425.	62898.75
GT 8.0 AND LTE 18.0	LTE	1.0	0.	0.0
GT 8.0 AND LTE 18.0	GT 1.0+LTE	8.0	0.	0.0
GT 8.0 AND LTE 18.0	GT 8.0+LTE	18.0	151.	1829.09
GT 8.0 AND LTE 18.0	GT 18.0+LTE	55.0	51.	1481.51
GT 8.0 AND LTE 18.0	GT 55.0		27.	11535.96
		SUB TOTAL	229.	14846.55
GT 18.0 AND LTE 55.0	LTE	1.0	0.	0.0
GT 18.0 AND LTE 55.0	GT 1.0+LTE	8.0	0.	0.0
GT 18.0 AND LTE 55.0	GT 8.0+LTE	18.0	0.	0.0
GT 18.0 AND LTE 55.0	GT 18.0+LTE	55.0	64.	1974.77
GT 18.0 AND LTE 55.0	GT 55.0		37.	11497.35
		SUB TOTAL	101.	13472.12
GT 55.0	LTE	1.0	0.	0.0
GT 55.0	GT 1.0+LTE	8.0	0.	0.0
GT 55.0	GT 8.0+LTE	18.0	0.	0.0
GT 55.0	GT 18.0+LTE	55.0	0.	0.0
GT 55.0	GT 55.0		5.	2153.12
		SUB TOTAL	5.	2153.
FLOW PATH= 11 SMALL DIMENSION *** TOTAL			20440.	269915.43

EXHIBIT G

DEVELOPMENT OF INTERNAL FLOW DATA

To develop the direct variable cost for handling and storing materiel at a depot, the workload within each work station is needed. Overall throughput volumes (receipts and issues) and storage requirements (assets) are developed from the DODMDS Study Group automated data base. In this Exhibit, the methods and procedures used in manipulating these overall requirements to develop individual work station requirements are shown.

The objective of this effort was to develop factors (percentages) that could be applied to the overall inbound and outbound throughput volumes to estimate the amount of materiel moving through each work center.

Primary information sources, important procedures used, and the basic flow and combinations of data are shown in Schedule G-I. In essence, the sample volumes collected in response to the Study Group Facilities Data Call were used to develop flow factors on a depot-specific basis. These factors (inbound, mode mix, percentage of materiel requiring inspection and testing, percentage of materiel requiring packaging and preservation, etc.) were then converted to DODMDS product group-specific factors using a translation program based on the throughput volume of each product group at each depot (DODMDS Report A1.61). These factors, called primary flow factors, for each product group are listed in DODMDS Report A1.62. Schedule G-IV is a sample page from this Report.

Shipment characteristics by DODMDS product group were used to combine the primary flow factors shown in Schedule G-IV into factors by flow path. Flow path-specific primary flow factors are shown in Schedule G-V.

In addition to primary flow factors, three other internal depot flow factors were developed.

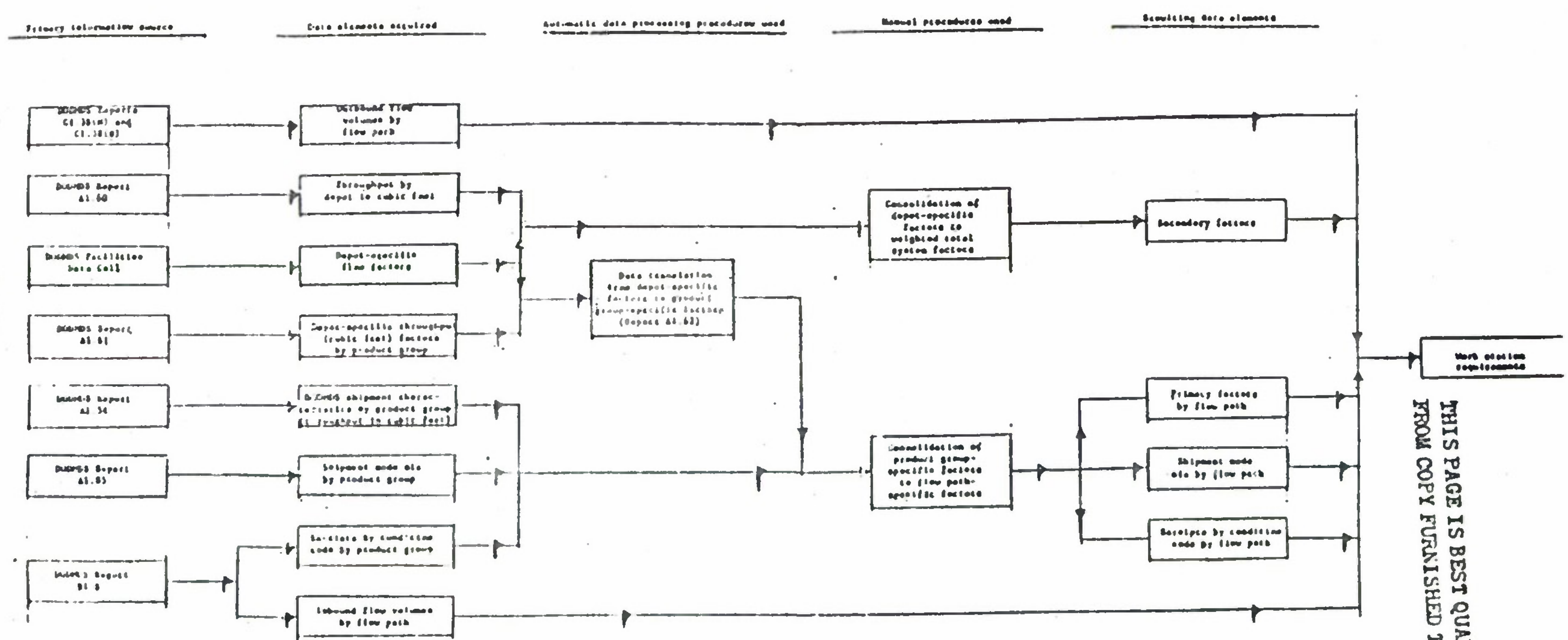
1. Secondary factors, also derived from the Facilities Data Call, were consolidated into total system values using the total volume, in cubic feet, shipped from each depot (DODMDS Report A1.60). These secondary factors are listed in Schedule G-VI.

2. Receipts by condition code, extracted from the DODMDS data base in Report B1.6 for each product group, were consolidated into flow path values using DODMDS Report A1.62. These receiving characteristics, shown in Schedule G-VII, were used to develop the workload spilt between new procurement and returns inspection.

3. Outbound volumes by traffic mode, summarized by product group in DODMDS Report A1.95, were consolidated into flow path values also using DODMDS Report A1.62. These shipment mode mix factors are shown in Schedule G-VIII.

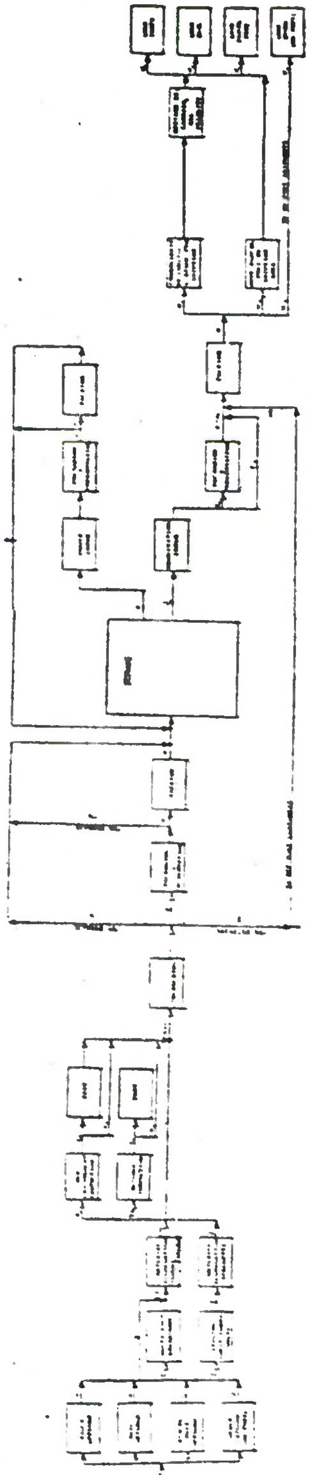
The overall flow through a typical depot is illustrated by the flowchart shown in Schedule G-II. This chart was developed using the more detailed flowcharts prepared for the Study Group and approved by the Services and DLA as guides. Individual work centers and the interaction between work centers are shown, with alpha symbols used to indicate flow values.

Explanation of the symbols, values developed for Flow Path No. 11-small items, and sources of each value are listed in Schedule G-III.



Schedule G-I

Work Station Requirements Development



Schedule G-II

Internal Depot Flowchart

Schedule G-III

Flowchart Explanation

Flow Path No. 11

Description All other -- small

Flowchart symbol	Flow description	Flow volume	Information source
a_1	Total inbound (receipt) volume	1/	Report B1.6 2/
a	Materiel received via truck	71% of a_1 by cube	Data Call p.P.30.2, 2/
b	Materiel received via rail	13% of a_1 by cube	Data Call p.P.30.2, 2/
c	Materiel received via Parcel Post, UPS, Federal Express, etc.	2% of a_1 by cube	Data Call p.P.30.2, 2/
d	Materiel received via intradepot transport system	14% of a_1 by cube	Data Call p.P.30.2, 2/
e	Materiel received on mixed pallets or in multi-packs	17% of a_1 by cube	Data Call p.P.30.2, 2/ and Report B1.6
f	Materiel received on solid pallets or skids	79% of a_1 by cube	Data Call p.P.30.2, 2/ and Report B1.6
g	Materiel received unpalletized-single items	4% of a_1 by cube	Data Call p.P.30.2, 2/ and Report B1.6
h	Materiel received requiring inspection	23% of a_1 by cube	Primary Flow Factor -- Reports A1.54 and A1.62
h_1	New procurement materiel requiring inspection	78% 3/ of h by cube	Report B1.6 2/
h_2	"Returns" materiel requiring inspection	22% 3/ of h by cube	Report B1.6 2/
h_3	New procurement materiel requiring inspection and testing	1% of h_1 by cube	Reports A1.54 and A1.62
h_4	New procurement materiel requiring inspection but not testing	99% of h_1 by cube	Reports A1.54 and A1.62
h_5	"Returns" requiring inspection and testing	1% of h_2 by cube	Reports A1.54 and A1.62
h_6	"Returns" requiring inspection but not testing	99% of h_2 by cube	Reports A1.54 and A1.62
i	Materiel received not requiring inspection	77% of a_1 by cube	Reports A1.54 and A1.62
j	Materiel going directly to storage from inchecking	86% of a_1 by line items	Reports A1.54 and A1.62
k	Materiel requiring P&P prior to storage	13% 4/ of a_1 by line items	Reports A1.54 and A1.62
m	Materiel bypassing storage destined for off-post customers (backorders)	1% of a_1 by line items	Reports A1.54 and A1.62
o	Materiel requiring P&P and packing prior to storage	50% 5/ of k by line items	Reports A1.54 and A1.62
p	Materiel requiring P&P but not packing prior to storage	50% 5/ of k by line items	Reports A1.54 and A1.62
q	Materiel requiring a COMIS function	2% 6/ of t by line items	Reports A1.54 and A1.62
r	Materiel requiring a COMIS function but not packing	50% 5/ of q by line items	Reports A1.54 and A1.62
s	Materiel requiring a COMIS function and packing	50% 5/ of q by line items	Reports A1.54 and A1.62
t	Materiel pulled from storage for shipment	1/	Reports C1.3B(M) and C1.3B(N)
t_1	Requisitioned materiel requiring P&P prior to shipment	9% of t by line items	Reports A1.54 and A1.62
t_2	Requisitioned materiel not requiring P&P prior to shipment	91% of t by line items	Reports A1.54 and A1.62
u	Materiel requiring packing prior to shipment (total shipping volume)	101% 7/ of t 1/	Reports C1.3B(M) and C1.3B(N)
u_1	Materiel shipped off-base excluding Parcel Post, UPS and Federal Express shipments	71% of u by weight	Report A1.95

Flowchart symbol	Flow description	Flow volume	Information source
u_2	Materiel shipped via Parcel Post, UPS, Federal Express, etc.	6% of u by weight	Report A1.95
u_3	On-post shipments	23% of u by weight	Report A1.95
v_1	Off-post shipments via PP, UPS, Federal Express, etc.	6% of u by weight	Report A1.95
v_2	Off-post shipments via truck	66% of u by weight	Report A1.95
v_3	Off-post shipments via rail	5% of u by weight	Report A1.95
v_4	On-post shipments	23% of u by weight	Report A1.95

1/Volume from EDP output report for specific level of throughput volume.
2/Weighted average of all depots by throughput (in cubic feet).
3/Assume condition code "A" receipts to be new procurement and "all other" condition code receipts to be returns.
4/Volume routed directly to P&P from receiving plus P&P incident to receipt volume.
5/Based on volume to packing incident to receipt being 50 percent of volume to P&P incident to receipt.
6/Percent P&P incident to COMIS.
7/u = t + m = 101% of t. Assume inbound = outbound.

Schedule G-IV

Primary Flow Factors by Product Group

(Sample pages from DODMDS Report A1.62)

FLOW FCTRS	101	102	104	111	121	131	132	181	182
RECEIVING									
CUBE/PALL	26.708	21.317	17.297	.000	9.223	.000	.000	12.160	16.926
CUBE/SHPC	1.859	2.930	5.596	.000	2.748	.000	.000	2.770	1.671
CUBE/LGPC	26.192	27.227	35.376	.000	13.181	.000	.000	20.658	22.267
CUBE/MPPC	10.365	8.704	7.280	.000	2.191	.000	.000	9.096	2.971
PCT INSP	.351	.320	.267	.000	.299	.000	.000	.206	.218
PCT TEST	.012	.014	.001	.000	.008	.000	.000	.009	.011
PCT BYPASS	.639	.618	.233	.000	.747	.000	.000	.708	.768
PCT ONBASE	.219	.232	.230	.000	.279	.000	.000	.256	.247
PCT STORE	.296	.731	.792	.000	.697	.000	.000	.689	.673
PCT PACKGE	.029	.027	.070	.000	.011	.000	.000	.082	.078
PCT OFFBSE	.006	.006	.007	.000	.009	.000	.000	.012	.018
PACKING									
PCT REC	.049	.040	.020	.000	.019	.000	.000	.052	.098
PCT OFFBSE	.706	.224	.761	.000	.747	.000	.000	.729	.660
PCT ONBSE	.293	.272	.290	.000	.216	.000	.000	.272	.240
PPI SMREC	9.839	6.303	2.982	.000	6.270	.000	.000	6.227	6.118
PPI LGREC	3.933	6.008	9.603	.000	9.869	.000	.000	5.012	5.529
PPI SMSHIP	1.991	1.209	1.002	.000	1.003	.000	.000	1.001	1.006
PPI LGSHIP	2.119	1.632	1.078	.000	1.298	.000	.000	2.000	2.980
PPI CONIS	190.022	129.692	19.292	.000	12.817	.000	.000	29.676	60.690

FLOW ITEMS	101	102	108	111	121	131	132	184	192
PRES/PACK									
PCT REC	.063	.079	.059	.000	.163	.000	.000	.205	.220
PCT SHIP	.260	.216	.066	.000	.055	.000	.000	.372	.962
PCT COMIS	.011	.020	.084	.000	.049	.000	.000	.017	.016
PPI SMREC	18.112	22.205	12.337	.000	8.339	.000	.000	23.666	31.667
PPI LGREC	19.864	13.016	6.581	.000	9.296	.000	.000	5.061	6.564
PPI SMSHIP	7.960	7.993	6.079	.000	1.777	.000	.000	2.987	9.064
PPI LGSHIP	6.696	8.270	8.115	.000	2.301	.000	.000	9.169	9.599
PPI COMIS	38.312	90.330	10.765	.000	26.196	.000	.000	16.256	21.060
SHIPPING									
CUBE/PALL	35.296	32.519	27.209	.000	96.162	.000	.000	39.127	38.678
CUBE/SMPC	8.151	6.533	3.202	.000	3.325	.000	.000	3.986	5.029
CUBE/LGPC	95.937	96.791	17.699	.000	8.209	.000	.000	30.812	93.129
CUBE/MPPC	9.762	8.226	6.723	.000	5.519	.000	.000	11.013	16.669

Schedule G-V

Primary Flow Factors by Flow Path

Flow factors	4	5	6	7	8	9	1-3,10,11
Receiving							
Percent inspected	.351	.392	.248	.390	.185	.130	.230
Percent tested	.012	.018	.005	.010	.005	.010	.002
Percent bypassed	.634	.591	.748	.599	.812	.860	.771
Percent on base	.214	.101	.193	.171	.147	.025	.123
Percent stored	.746	.863	.699	.786	.802	.830	.802
Percent packaged	.024	.022	.085	.033	.043	.140	.058
Percent off base	.008	.015	.025	.009	.010	.008	.008
Packing							
Percent received	.44	.019	.080	.036	.055	.109	.036
Percent off base	.706	.818	.778	.711	.815	.952	.830
Percent on base	.293	.182	.222	.289	.186	.048	.172
Packaging and preservation							
Percent received	.063	.039	.102	.078	.067	.025	.074
Percent shipped	.260	.047	.022	.268	.298	.010	.085
Percent COMIS	.011	.013	.018	.021	.015	.009	.015

Source: DODMDS Reports A1.54 and A1.62.

Schedule G-VI

Secondary Flow Factors

Type of flow	Weighted flow factor[a] (percent)
Receipts via truck	71
Receipts via rail	13
Receipts via parcel post	2
Receipts via other modes	14
Total	100
Receiving characteristics	
Mixed pallets or multipacks	17
Solid pallets or skids	79
Nonpalletized and single item	4
Total	100
New procurement inspection	50
Return inspection	50
Total	100

Source: DODMDS Study Group data call response.

[a] Depot-specific responses weighted by shipment cube per depot.

Schedule G-VII

Receipts by Condition Code

Flow path number	Description	Condition code "A" Receipt cube (1,000 cubic feet)	Condition code "A" Per-cent-age	Condition code "B" Receipt cube (1,000 cubic feet)	Condition code "B" Per cent-age	Condition code "C" Receipt cube (1,000 cubic feet)	Condition code "C" Per-cent-age	Condition code "other" Receipt cube (1,000 cubic feet)	Condition code "other" Per-cent-age	Total Receipt cube (1,000 cubic feet)	Total Per-cent age
4	Small arms	19,514	35	209	-	-	-	36,422	65	56,145	100
5	Ships and boats	300,818	28	-	-	-	-	792,656	72	1,093,474	100
6	Aircraft engines	222,697	44	520	-	1	-	287,625	56	510,843	100
7	Vehicles	1,390,354	32	433,863	10	-	-	2,534,790	58	4,359,007	100
8	Tires	719,131	90	10,212	1	-	-	75,028	9	804,371	100
9	Subsistence	2,820,447	99	5,471	-	566	-	16,520	1	2,843,004	100
1-3,10,11	All other commodities	12,333,251	78	61,687	-	6,661	-	3,455,822	22	15,857,421	100
	Total	17,806,212	70	511,962	2	7,228	-	7,198,863	28	25,524,265	100

Source: DODMDS Report B1.6.

Schedule G-VIII

Shipments by Mode by Flow Path

Flow path number	Description	LTL Shipment weight (1,000 cwt.)	LTL Percentage	TL Shipment weight (1,000 cwt.)	TL Percentage	CL Shipment weight (1,000 cwt.)	CL Percentage	PP Shipment weight (1,000 cwt.)	PP Percentage	Local Shipment weight (1,000 cwt.)	Local Percentage	Total Shipment weight (1,000 cwt.)	Total Percentage
4	Small arms	53	42	23	18	2	2	6	5	42	33	126	100
5	Ships and bnats	91	11	55	6	39	5	4	-	673	78	862	100
6	Aircraft enginee	305	30	102	10	-	-	1	-	615	60	1,023	100
7	Vehicles	164	3	1,551	29	1,408	26	18	-	2,254	42	5,395	100
8	Tires	197	54	83	23	15	4	14	4	57	15	366	100
9	Subsistence	7,891	91	549	6	2	-	7	-	225	3	8,674	100
1-3, 10, 11	All other commodities	6,449	33	6,426	33	990	5	1,196	6	4,509	23	19,570	100
	Total	15,150	42	8,789	24	2,456	7	1,246	4	8,375	23	36,016	100

Snurce: DODMDS Report A1.95.

SECTION 6
FORECAST OF TECHNOLOGICAL CHANGES INFLUENCING DEPOT OPERATING COSTS

HIGHLIGHTS

1. Quantitative Highlights

For purposes of developing depot operating cost curves, our investigations indicated that:

- Between 1976 and 1986 all areas of depot costs are expected to increase. The cost of materials handling and storage equipment will rise at a lesser rate than costs of labor and space. Equipment will become increasingly easier to justify on the basis of labor and/or space savings. The expected increase in each cost area is:

Depot cost area	Expected cost increase -- 1976-1986 (percent)
Labor	90
Construction (space)	84
Equipment	70
Supplies	58

- Individual categories of materials handling and storage equipment are expected to increase in cost as shown below. The largest increases in costs are expected for fixed path horizontal transport equipment and conveyor peripheral devices. The smallest increases are anticipated for computers, controllers, and intelligence acquisition devices.

Equipment category	Expected cost increase -- 1976-1986 (percent)
Storage aids	69
Storage and retrieval machines	71
Cranes and hoists	69
Lift trucks	75
Mobile horizontal transport equipment	74
Fixed path horizontal transport equipment	92
Conveyors	87
Conveyor peripheral devices	92
Computers and controllers	27
Intelligence acquisition devices	14
Weighted average	70

- Factors tending to increase equipment costs are: the demand for greater throughput, increased stacking heights, and greater reliability; more restrictive safety requirements; and the need for greater control sophistication.

- Factors tending to reduce equipment costs are: improved design; more efficient manufacturing and installation techniques; new materiels; and the use of advanced electric/electronic devices and systems.

2. Qualitative Highlights

- Significant changes in equipment costs will result from the total systems approach to warehouse design. Relatively few improvements are expected to basic equipment components, nor are revolutionary new components anticipated to be made available. Instead, major improvements will be due to more effective use and arrangement of existing components made possible by advances in computers, and control devices and techniques.

- Many potential improvements to equipment components are technically feasible but are physically constrained by other limiting factors. For example: travel speeds of unit load handling devices and conveyors can be increased, but the practical degree of

increase is limited by load stability, acceleration/deceleration, and load/unload work-station capacity constraints.

- Gains in productivity of equipment components are expected but will not be of a significant magnitude in relation to cost changes. Lack of pressure felt by manufacturers to increase equipment productivity is the primary reason.

EXECUTIVE SUMMARY

A. INTRODUCTION

A principal objective of the Department of Defense Materiel Distribution System Study is to develop and evaluate alternative wholesale distribution system configurations. These configuration alternatives, which include the number, location, and basic missions of depots, are to be evaluated for cost and service attributes using, among other factors, three sets of depot operating cost as input data:

- Historical depot operating costs based on actual costs experienced during Fiscal Year 1975,
- Nominal depot operating costs, which are engineered costs disregarding the facilities and equipment at existing locations. Nominal operating costs include annualized investment costs for new facilities and equipment reflecting the current state-of-the-art in materials handling and storage.
- Future depot operating costs based on technological changes that are anticipated over the next ten years (1976-1986).

The objective of the effort summarized in this Report is to provide the insight and data needed to develop these future depot operating costs. This overall objective is reached by completing three distinct steps:

1. Identification of the technological changes expected during the next ten years.
2. Assessment of the impact of these changes on the major depot operating cost areas.
3. Integration of the resulting cost changes into nominal depot operating costs and development of a set of future depot operating cost curves.

B. DEVELOPMENT OF FORECAST FACTORS

The major areas affecting direct variable depot operating costs are equipment, labor, space, and supplies. The expected increase, during the next ten years, in each of these cost areas is shown in Figure 1, Cost Forecast Summary. Materials handling and storage equipment cost is expected to rise 70 percent by 1986. The anticipated 90 percent increase in labor cost represents the greatest rise of the four cost areas. Construction (space) costs and costs of supplies are expected to rise 84 and 58 percent, respectively. Because labor represents a significant portion of construction costs, there is a similarity between the increases expected in these two cost areas.

1. Equipment Cost Forecast

The investigation to ascertain expected technological changes in materials handling and storage equipment represents the major portion of the forecasting effort. Suppliers and users of equipment, from both the public and private sectors, were interviewed personally, and by mail, using a followup questionnaire. Resulting qualitative and quantitative information regarding equipment changes is a summary of the collective judgment of these knowledgeable figures in the materials handling field.

Important conclusions drawn from the equipment portion of the depot forecast are:

a. Significant changes in equipment costs will result from the total systems approach to warehouse design. Few improvements are expected to basic equipment components, nor are revolutionary new components anticipated to be made available. Instead, major improvements will be due to more effective use and arrangement of existing components, made possible by advances in computers, and control devices and techniques.

b. Many potential improvements to equipment components are technically feasible but are constrained by other limiting factors. For example: travel speeds of unit load handling devices and conveyors can be increased, but the practical degree of increase is limited by load stability, acceleration/deceleration, and load/unload work-station capacity constraints.

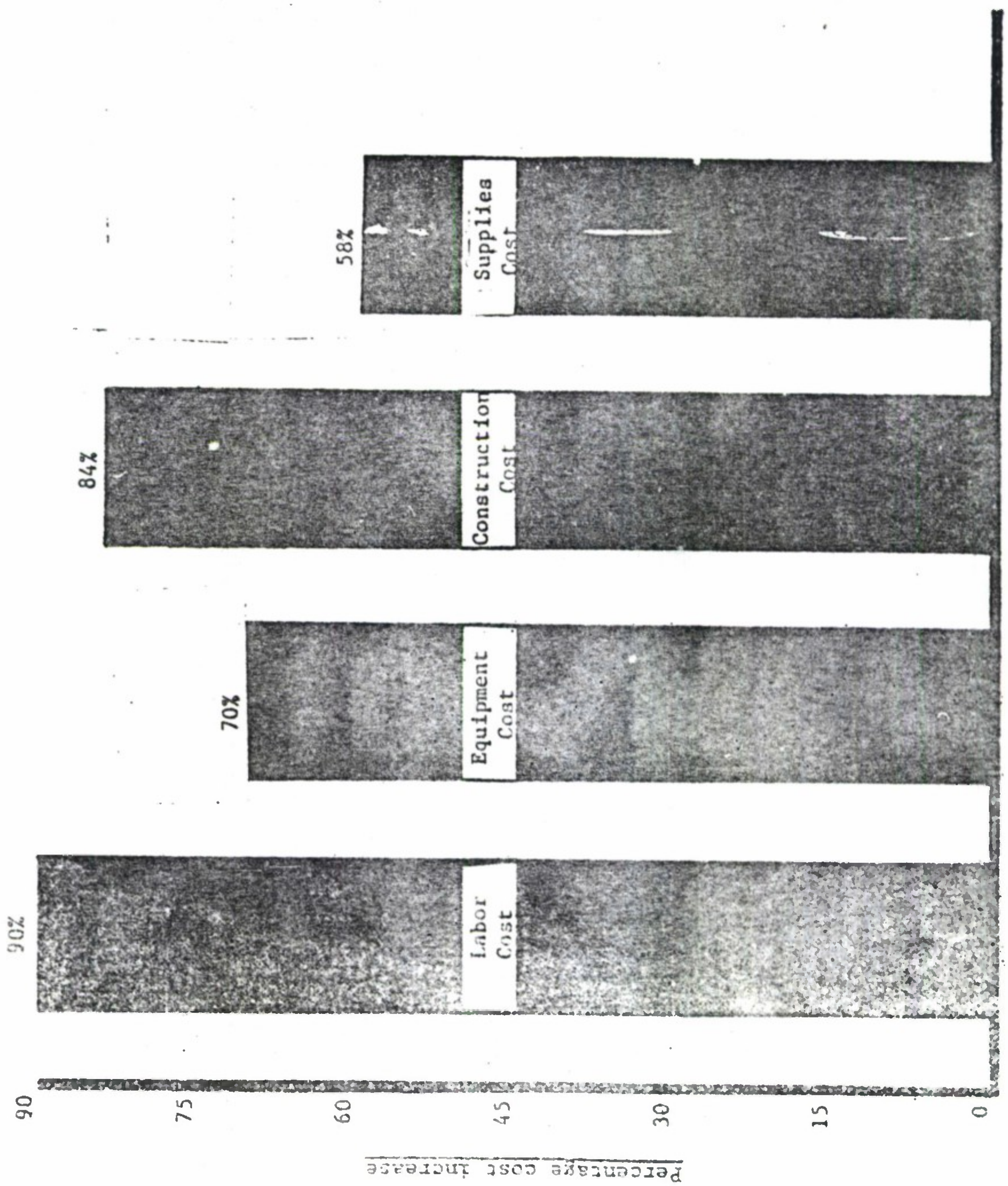


Figure 1

Cost Forecast Summary

(1976-1986)

c. Since the cost of equipment is expected to rise less than those of labor and space, it will become increasingly easier to justify equipment on the basis of space and/or labor savings in the future.

d. The factors most responsible for equipment cost changes are:

(1) Greater throughput
(2) Greater reliability
(3) More restrictive safety requirements
(4) Increased stacking heights
(5) Control sophistication
(6) Improved design
(7) More efficient manufacturing techniques
(8) New materials
(9) More efficient installation techniques
(10) Advanced electric/electronic devices and systems.

The percentage cost change due to each of these factors, on each category of materials handling and storage equipment, is shown in Figure 2, Summary Equipment Cost Matrix. In this Figure, the net change due to all cost factors is shown, and a forecast factor calculated for each equipment category. The forecast factor represents the total change in cost anticipated for each equipment category including the application of a ten-year inflation factor of 1.61 (approximately five percent annually compounded).

e. The largest increases in equipment costs are expected to result from more restrictive safety requirements and increased control sophistication.

f. Design improvements and more efficient manufacturing techniques are expected to produce the greatest decreases in equipment costs, prior to the application of the inflation factor.

g. All categories of equipment are expected to increase in cost close to or above the weighted average of 70 percent with the notable exceptions of computers and controllers, and intelligence acquisition devices.

2. Equipment Productivity Forecast

Equipment productivity is influenced by similar factors as is equipment cost. Anticipated changes in equipment productivity are summarized in Figure 3, Equipment Productivity Summary.

Equipment categories	Cost factors: Greater through-put	Greater relia-bility	More restric-tive safety require-ments	In-creased stack-ing heights	Control sophis-tication	Im-proved design	More effi-cient manu-factur-ing tech-niques	New mate-rials	More effi-cient instal-lation tech-niques	Advanced electric/electronic devices and systems	Net change[a]	Fore-cast factor[b]
Storage Aids	+1	N/A	+5	+2	N/A	-1	-2	0	0	N/A	+5	1.69
Storage/Retrieval Machines	+5	+3	+5	+2	+6	-6	-3	0	-1	-5	+6	1.71
Cranes and Hoists	+1	+1	+4	N/A	+2	-2	0	0	-1	0	+5	1.69
Lift Trucks	+3	+2	+3	+3	+2	-2	-1	0	N/A	-1	+9	1.75
Mobile Horizontal Transport Equipment	+2	+1	+2	N/A	+6	0	-1	0	-1	-1	+8	1.74
Fixed Path Horizontal Transport Equipment	+10	+5	+8	N/A	+5	-5	-3	0	-1	0	+19	1.92
Conveyors	+4	+6	+9	N/A	+11	-6	-3	-1	-3	-1	+16	1.87
Conveyor Peripheral Devices	+12	+5	+9	N/A	+9	-7	-4	0	-3	-2	+19	1.92
Computers and Controllers	0	0	N/A	N/A	+6	-9	-5	-5	-8	N/A	-21	1.27
Intelligence Acquisition Devices	+1	+3	N/A	N/A	+7	-6	-23	-8	-3	N/A	-29	1.14

N/A -- Not applicable.

[a]Net cost change excluding inflation.
[b]Forecast factor = net change adjusted to include inflation.

Figure 2

Summary Equipment Cost Matrix

(Percentage cost increase/decrease, 1976-1986)

Influencing factor	Anticipated change in equipment productivity Increase	Decrease	No change
Greater throughput	X		
Greater reliability	X		
More restrictive safety requirements		X	
Increased stacking heights			X
Control sophistication	X		
Improved design	X		
More efficient manufacturing techniques			X
New materiels			X
More efficient installation techniques			X
Advanced electric/electronic devices and systems	X		

Figure 3

Equipment Productivity Summary

(1976-1986)

Productivity is expected to increase as a result of customer demand for greater throughput, greater reliability, and more sophisticated control techniques and devices, as well as manufacturer emphasis on design improvements.

More restrictive safety requirements, resulting from OSHA regulations and standards developed by other governing bodies, will tend to drive equipment productivity down.

No change to equipment productivity is anticipated to result from increased stacking heights, more efficient techniques of manufacturing or installation, or new materials.

In general, equipment productivity gains are anticipated over the next ten years, but not of a magnitude considered significant in comparison to expected cost changes.

3. Labor Cost Forecast

Labor at Department of Defense depots for materials handling and storage activities is primarily civilian and the forecast of labor cost is based on DOD projections for civilian labor. The ten-year increase of 90 percent represents an approximate seven percent annual increase in civilian hourly wage rates. Examination of historical labor rates and future projections shows that civilian pay rose at approximately four percent annually from 1960 to 1969. The seven percent annual rise began in 1969 and is expected to continue to 1986.

4. Construction Cost Forecast

The cost of new construction, or space cost, is expected to rise by 84 percent between 1976 and 1986. This projection is developed using a technique known as historical analogy and regression. Historical unit (cost per square foot) costs for warehousing-type structures are compared with historical values of known economic indicators (in this case, the Gross National Product Index and the Consumer Price Index) that also have available forecasted values. If a good correlation between historical trends of a construction index and an economic indicator exists, the construction index is projected using the economic indicator forecast as a guide.

In this instance, a correlation coefficient of nearly 1.00 is produced by comparing one of the major historical construction cost

indices with the GNP Index. Thus, this pair of indices is used to develop the construction cost forecast with a high degree of confidence.

5. Supplies Cost Forecast

The 58 percent increase in the cost of supplies during the 1976-1986 timeframe is derived from the DOD Forecast for Operating and Maintenance (O&M) costs.

C. COST DEVELOPMENT

Current state-of-the-art nominal depot costs were developed by using materials handling flow path approach. Forecast costs are developed by applying the appropriate projection factor to each major cost element -- space, labor, equipment and supplies -- as determined in the development of current state-of-the-art nominal depot costs.

Unit costs (dollars per hundredweight of throughput) for 1986 are listed by flow path in Figure 4. Annual unit cost values are shown for both maximum and minimum throughput levels in this Figure.

The relative significance of each cost element in the total system cost is summarized in Figure 5. Space cost is the dominant element at both the minimum and maximum throughput levels.

Flow paths		Unit costs[a] ($/cwt.)	
Number	Description	At maximum throughput level	At minimum throughput level
1	Cold	164.67	326.67
2	Hazardous	1.47	3.52
3	Security	8.97	43.87
4	Small arms	17.96	22.68
5	Ships/boats, etc.	3.17	3.92
6	Aircraft engines	6.42	14.46
7	Vehicles	3.84	9.86
8	Tires	6.28	11.11
9	Subsistence	1.16	1.67
10	Large items	21.94	55.37
11	Small items	12.95	15.31
	Total system average	9.15	16.98

[a] Cost values for Depot Grouping (Region) II.

Figure 4

Unit Handling and Storage Forecast Costs

Cost element	At maximum throughput level: Total annual cost[a] (millions of dollars)	At maximum throughput level: Percent of total	At minimum throughput level: Total annual cost[a] (millions of dollars)	At minimum throughput level: Percent of total
Space	160	42	7.8	44
Equipment	73	19	5.5	31
Labor	137	36	4.1	23
Supplies	10	3	0.3	2
Total	380	100	17.7	100

[a] Depot Grouping (Region) II values.

Figure 5

Handling and Storage System Cost Elements

CHAPTER 1
INTRODUCTION

A. BACKGROUND

One of the primary objectives of the Department of Defense Materiel Distribution System Study is to develop and evaluate wholesale distribution system configuration alternatives. Each configuration alternative includes the number of depots; depot locations; and the mission of each depot in terms of commodities stored and handled, and the level of throughput activity by commodity. The service levels and annual operating costs resulting from each alternative configuration are calculated. Annual operating costs are developed for materials handling and storage activities at each depot, for each transportation link external to the depots, and in total. Required investment costs, to the extent necessary for evaluation of a configuration alternative, are developed.

The study effort includes the development and evaluation of distribution system configuration alternatives under three basic scenarios regarding depot operating cost, as well as under combinations of these scenarios. The scenarios are:

1. Historical Depot Costs

In this scenario, configuration alternatives using handling and storage costs for commodities based on historical depot operating costs are evaluated. Alternative configurations result essentially from relocating commodities to depot locations having the lowest operating cost for those commodities, in combination with the optimum transportation network.

2. Nominal Depot Costs

Nominal depot operating costs are defined as those annual operating costs, including annualized investment costs for new space and equipment, that would be incurred if an entirely new wholesale distribution system were constructed with no constraints imposed by existing facilities or systems. These nominal costs are engineered costs and assume effective labor scheduling and control. In essence, configurations based on nominal depot operating costs disregard completely facilities and equipment at existing locations.

Equipment, facilities, and methods utilized in developing nominal depot costs reflect the current state-of-the-art in technology and management practices.

3. Future Depot Costs

This scenario includes configuration alternatives in which depot operating costs are based on nominal costs and concepts projected ten years into the future (1976-1986).

Consideration of future wholesale distribution system configurations, as part of the DODMDS Study, should assist in avoiding short-term decisions that might preclude long-term goals.

It is this last scenario that requires the development of a forecast to project depot operating cost components to the 1986 design year. To this end, Drake Sheahan/Stewart Dougall, as part of its technical support to the DODMDS Study Group under Contract N00600-76-C-0508 (31 October 1975), has completed an investigation of anticipated changes in materials handling and storage operating concepts and the associated anticipated cost changes within the 1976-1986 timeframe in order to provide itself with inputs for developing future operating cost curves. This Report is a summary of the results of the forecast investigation.

B. OBJECTIVES OF THE FORECAST

The depot forecast has one principal objective:

- To develop factors for application to current state-of-the-art cost curves to produce a set of future depot operating cost curves.

In order to attain this objective, three steps are required:

1. Identification of changes and trends in materials handling and storage equipment and operating concepts expected during the next ten years.

2. Assessment of the impact of these anticipated changes in components and concepts on equipment costs and development of ten-year equipment cost projection factors. Concomitant with this step is the development of projection factors for other segments of depot operating costs (space, labor, and supplies costs).

3. Application of the ten-year projection factors to the appropriate areas of the nominal depot costs to develop a set of costs that will reflect technology and costs in the 1986 design year.

C. MAJOR AREAS OF INTEREST AND CONCLUSIONS

Since the primary areas affecting depot cost are equipment, labor, space, and supplies, the anticipated changes that impact these costs are the major items of interest in the forecast. Each area has been investigated separately and individual cost projection factors developed.

Insight into expected changes in equipment technology and costs represents the major segment of the forecast investigative effort. Important conclusions drawn from our research and evaluation effort regarding anticipated equipment developments are:

1. The most significant changes in equipment costs during the next ten years will result from the total systems approach to warehouse design.

Few improvements are expected to basic materials handling and storage equipment components, nor are significant new components anticipated to be made available. The major improvements will instead be in the design and installation of complete systems utilizing several individual components. These improvements will result from more efficient use and arrangement of existing components made possible primarily by improvements and cost reductions in control devices.

Since the effect of this total systems approach is already reflected in the development of current state-of-the-art nominal depot cost curves, it is not a recognizable factor in the forecast.

2. In many cases, potential improvements to equipment components are technically feasible but are restricted by other related factors. For example: travel speeds of unit load handling devices can be increased, but significant increases are limited by load stability and acceleration/deceleration constraints. Also, conveyor speed increases are limited by load and unload operations. Another example is that of high-rise storage systems: racks for heights over 60 feet are practical to design and build, but their high cost makes them difficult, if not impossible, to market.

3. An overall increase of 70 percent in equipment cost can be expected within the next ten years.

4. Since the cost of equipment is expected to rise less than those of labor and space, it will be increasingly easier to

justify equipment on the basis of labor and/or space savings in the future.

5. Before taking inflation into account, the largest increases in equipment costs are expected to result from more restrictive safety requirements and increased sophistication of controls. The greatest decreases in equipment costs are expected to result from design improvements and more efficient manufacturing techniques.

6. Before considering the effect of inflation, most categories of materials handling and storage equipment will increase in price. Notable exceptions are computers, controllers, and intelligence acquisition devices.

7. Productivity gains in equipment components are expected but are not significant in comparison to anticipated cost increases.

Ten-year projection factors for labor, space, and supplies costs are:

a. Hourly Wage Rates are expected to increase by 90 percent between 1976 and 1986. This increase represents an approximate seven percent annual rise in labor rates and is based upon projections supplied by the Department of Defense.

b. The unit (per square foot) cost of Space or new construction cost is expected to rise by 84 percent over the ten-year period. Since construction costs are essentially a combination of costs of labor and materials, it is not surprising that the trend in space cost is similar to that of labor.

c. Costs of Supplies are expected to increase by 58 percent over the next ten years.

D. METHODOLOGY

Two forecasting techniques were used to develop the data and qualitative information summarized in this Report. Knowledgeable people in the area of materials handling and storage, representing both the public and private sectors, were polled, and their ideas and responses to specific questions weighted and summarized. Secondly, available historical trend data and existing forecasts were evaluated and utilized.

A review of available literature and personal interviews with major equipment suppliers and users were employed to categorize materials handling and storage equipment into logical groups for analysis, and to identify the important factors influencing equipment cost, productivity, and operating changes. Followup questionnaires to the interviewees were used to quantify cost projections.

Anticipated changes in labor, space, and supplies costs are essentially a function of forecasts previously completed within the Department of Defense or by other commercial and governmental groups. The sources of these projections were investigated, their results examined, and those considered most reliable summarized in a suitable format for application to cost curve development.

The forecast effort, being a research project involving the reporting of findings whatever they may be, requires few planning assumptions. The planning assumptions used are listed in Exhibit A.

E. CONTENTS OF THE REPORT

The remainder of this Report consists of two Chapters and five Exhibits containing supporting documentation for the materiel discussed in the Chapter text.

Chapter 2, Development of Forecast Factors, includes a summary of the qualitative and quantitative results of the investigation, and the methodology and approach used in developing projection factors for labor, space, support, and equipment costs based upon anticipated changes. Materials handling and storage equipment is categorized into usable groupings for analysis and those factors and changes influencing equipment cost identified in "A". "B" describes the methodology used to develop projection factors for equipment. Anticipated changes in equipment and the resulting cost changes are discussed in detail, by equipment category, in "C".

The development of ten-year projection factors for application to labor, space, and supplies cost components of nominal depot costs is described in "D," "E," and "F," respectively.

Chapter 3, Cost Development, includes a description of the approach used to generate Forecast costs and a presentation of the results of this projected cost development.

CHAPTER 2
DEVELOPMENT OF FORECAST FACTORS

The direct operating cost of materials handling and storage systems is comprised of four major segments: space, labor, supplies and equipment cost. In this Chapter, the development and impact of anticipated changes in each of these cost areas from 1976 to 1986 are discussed.

Because equipment cost trends are more difficult to ascertain and quantify than are those for space, labor, and supplies, considerably more space is devoted to this subject. Also, anticipated changes in equipment productivity are presented as a corollary to the treatment of equipment cost.

A. EQUIPMENT COSTS AND PRODUCTIVITY

Information concerning anticipated changes in equipment costs and productivity was obtained largely through a series of field interviews with leading equipment suppliers and users. A list of these interviewees is shown in Exhibit B. In addition, a followup questionnaire was sent to these people, as well as to other leaders in the materials handling field (editors, educators, and industry professionals), to fully clarify and document their composite opinions.

By using this data gathering technique, we were able to identify the important factors that are expected to impact future equipment costs and productivity, and to categorize materials handling and storage equipment into major groups for analysis.

1. Factors Tending to Increase Equipment Cost

The five factors that are expected to increase equipment costs are:

a. Greater Throughput. The ability to hold or carry larger, heavier, or multiple loads, a higher processing rate capacity, and faster operating speeds all contribute to achievement of higher throughput.

b. Greater Reliability. Greater reliability can mean less downtime, less maintenance required, or greater accuracy of operation. Factors that can contribute to the realization of greater reliability include tighter tolerances, better testing methods, application of preventive maintenance diagnostic devices, improvements to shortlife components such as batteries, and improved durability of components.

c. More Restrictive Safety Requirements. These may take the form of additional safety devices being required as standard equipment, improvements in materiels to raise safety factors, reduced noise level requirements, etc. New, or more stringent, requirements may come as a result of building codes, OSHA rules, or changes in manufacturer or engineering association standards.

Potential insurance premium increases, resulting from the growing interest in product liability insurance, are included in this cost factor.

d. Improved Stacking Heights. Greater stacking height refers to increasing the practical height limitations of both storage aids and the devices used to put materiel into or retrieve materiel from storage. Cost increases can occur from the need for stronger materiels, more complex structures and/or controls, and increased alignment accuracy requirements.

e. Control Sophistication. Additional or advanced operating control devices and/or systems needed to expand equipment capabilities are included in this cost factor. For example, additional controls may allow a programmed unit to report the nature of a problem in case of a malfunction. Advanced controls may allow the unit to not only report the problem, but also to automatically correct and continue operating. The trend towards reducing the human element in equipment operation through automation requires the use of more sophisticated decision-making techniques.

2. Factors Tending to Reduce Equipment Cost

Five factors that are expected to reduce equipment costs were identified as:

a. Improved Design. This factor includes equipment design improvements such as operational simplification of mechanisms, less moving parts, and interchangeability of components. These improvements usually result from insight gained from operational experience, particularly with relatively new, automated equipment units.

b. More Efficient Manufacturing Techniques. Standardization of components, more modularity, and a reduction in custom-made units are typical manufacturing improvements. Increased market demand usually presents an opportunity for production line manufacturing operations with inherent economies of scale.

c. New Materiels. New or improved materiels that are less expensive, more durable, easier to work with, create less waste, or require less mass are likely to reduce the manufacturing cost and thus the selling price of equipment units.

d. More Efficient Installation Techniques. Increased installation efficiency can result from such improvements as methods standardization, more plant fabrication reducing the amount of field work, more efficient trouble-shooting methods, and a reduction in field wiring made possible by the increased use of multiplexing of control circuits.

e. Advanced Electrical/Electronic Devices and Systems. This factor includes on-board intelligence devices, programmable controllers, microprocessors, minicomputers, proximity switches, light-emitting diodes, and the associated software to provide operating instructions for these devices. Whereas the cost increase that may be anticipated from the addition of these devices is included above under the control sophistication factor, the cost of the devices themselves is expected to decrease.

3. Factors Influencing Equipment Productivity

Most of the factors that affect equipment cost also influence productivity. The effect of each factor on productivity is shown in Figure 2-1. It is expected that customer demand for greater throughput, greater reliability, and more sophisticated control techniques and devices, and manufacturer emphasis on equipment design improvements will tend to increase equipment productivity.

More restrictive safety requirements will have a negative effect on equipment productivity.

No change in productivity is anticipated to be caused by increased stacking heights, more efficient manufacturing techniques, new materiels, or more efficient installation techniques.

Influencing factor	Anticipated change in equipment productivity: Increase	Decrease	No change
Greater throughput	X		
Greater reliability	X		
More restrictive safety requirements		X	
Increased stacking heights			X
Control sophistication	X		
Improved design	X		
More efficient manufacturing techniques			X
New materiels			X
More efficient installation techniques			X
Advanced electric/electronic devices and systems	X		

Figure 2-1

Equipment Productivity Table

(1976-1986)

4. Equipment Categories

The categories of materials handling and storage equipment developed during our survey are listed below. Each category consists of functionally-related items or equipment subgroups that are needed to accurately develop cost factors.

a. Storage Aids — Racks, Bins, and Pallets.

(1) Racks include pallet racks and those racks incorporated in storage and retrieval systems, racks employed for the storage of unpalletized materiel which may or may not incorporate decking, special-purpose racks for specific item storage and stacking frames used with pallets.

(2) Bins include open and closed shelving fabricated from metal or wood which may or may not be subdivided into individual storage compartments.

(3) Pallets include all types of hardwood pallets and other than wood pallets (wire, steel, aluminum, plastic, etc.) including slave pallets needed for efficient use of specific storage and retrieval systems.

b. Storage and Retrieval Machines. This category encompasses all types of floor- or rail-mounted devices capable of depositing or withdrawing unit loads from either side of the line of machine travel at various levels of storage, including all interaisle transfer devices.

(1) Rail-mounted includes cranes which travel on floor-supported or overhead rails or both. These may be manual, requiring an operator traveling with the elevating platform and controlling its movements and the actions of the shuttle, or other mechanism used to transfer the load. These may also be automatic, employing no operator but with a control system to activate all motions under the direction of a keyboard, card reader, computer, or other means.

(2) Floor-mounted includes mobile lifting devices not confined to the storage aisle but performing storage and retrieval functions similar to the rail-mounted equipment. Guidance within aisles may be mechanical, using side guides, or electronic, using a buried wire or other means. These may be manual, in which the

operator controls all movements both in the aisle and outside, or automatic, wherein on-board electronics control the movements. For purposes of this discussion, swing reach lift trucks are classed as manual floor-mounted storage and retrieval machines.

c. Cranes and Hoists. This category covers all materials handling devices which lift, move, and lower materiel from an overhead structure. It includes both manual and powered hoists suspended from or incorporated in various crane structures. Portable hoists, mobile cranes, Gantry cranes, bridge cranes, and various "below-the-hook" attachments for use with any hoist are also included.

d. Lift Trucks. This category is divided into four subgroups as follows:

(1) Conventional Forklift Trucks which include counterbalanced units with sitdown center control or standup rear control, powered by battery or internal combustion engine.

(2) Narrow-Aisle Lift Trucks including straddle trucks, reach trucks and other rider types, capable of operating in aisles of less width than required for counterbalanced equipment.

(3) Walkies.

(4) Order Pickers. Manually-operated units with or without mechanical or wire aisle guidance, and with or without controls to automatically direct the vehicle to locations for manual picking.

e. Mobile Horizontal Transport Equipment. This category covers equipment capable of moving materiel horizontally on smooth, level surfaces in any direction including:

(1) Tractor-trailers. Any type of prime mover towing one or more detachable cars. May be driver-steered and controlled or may be wire-guided or radio-controlled, but capable of independent operation.

(2) Burden Carriers. Individually powered vehicles capable of transporting a load. May be driver-controlled or may be wire-guided but capable of independent operation.

(3) Handtrucks. Nonpowered burden carriers propelled manually.

(4) Pallet and Skid Jacks. Powered or nonpowered.

f. Fixed Path Horizontal Transport Equipment. This category includes all types of towlines and towline carts with in-floor or overhead chain propulsion.

g. Conveyors.

(1) Belt and Roller. This subgroup includes gravity conveyors of all types (skatewheel and roller); chutes and slides; powered belt conveyors, both roller bed and slider bed; live roller conveyor and accumulating conveyor.

(2) Overhead. This subgroup includes chain or cable driven trolley conveyor and power and free conveyor, both open and closed track.

h. Conveyor Peripheral Devices. This category includes various devices which may be incorporated into a conveyor system to enhance its usefulness for a given set of requirements.

(1) Sorters. All types of sortation devices such as push-off, pull-off, pop-up wheels, pop-up rollers, tilted belt, tilt-tray, tilt-slat, and sliding slat.

(2) Mergers. Devices for combining the flow of two or more conveyor lines in an orderly manner. These may be metering belt, sliding slat, skewed roller, or other types.

(3) Lifts, continuous or reciprocating.

(4) Palletizers and Depalletizers with feed and take-away conveyors.

(5) Shrink and Stretch Wrap Machines including manual and automatic bagging, feed conveyors, turntables and other associated devices.

(6) Strapping Machines.

(7) Other. All other peripheral devices in use or under development such as: packing aids, scales, electronic cubing and weighing devices, and load/unload stations.

i. Computers and Controllers. This category includes electronic devices such as programmable controllers, minicomputers and microprocessors which are or can be applied to the control of conveyors, storage and retrieval machines. order-picker trucks, and other materials handling devices.

j. Intelligence Acquisition Devices. This category includes system adjuncts which count, identify, or record location, or perform other command functions to updat computer records or initiate actions.

(1) Keyboards and CRT's. Manual input and display devices.

(2) Card and Tape Readers. Mechanized input devices.

(3) Code Readers. Fixed or automatic light beams to identify information appearing in coded form on containers.

(4) Voice Encoders. Devices which match sound inputs with a computerized memory for display, recording, or initiation of actions.

B. EQUIPMENT FORECAST METHODOLOGY

Field interviews and the experienced judgment of the BS/SD staff provide the basis for quantifying the anticipated change in equipment costs over the next ten years. The treatment of equipment productivity changes is developed using both quantitative and qualitative analysis. For reasons discussed in subsequent portions of this section, we conclude that equipment productivity changes will be insignificant in relation to cost changes. These productivity changes can thus be excluded from nominal depot cost curve development.

1. Equipment Costs

Ten-year percentage changes in equipment costs, excluding inflation, are displayed in Figure 2-2. Forecast cost changes are shown for each equipment category and subgroup according to the specific cost factor causing the expected impact. The net percentage change is calculated for each category and subgroup of equipment.

Since individual subgroups may represent a disproportionate level of importance in the DOD wholesale distribution system, subgroup weighting factors are used to develop an accurate total category change for each cost factor. These weighting factors represent the relative contribution of each equipment subgroup to the total DOD wholesale distribution system equipment cost. Systemwide equipment costs, as developed from the state-of-the-art nominal cost curve procedure, are listed in Figure 2-3. Subgroup and equipment category weighting factors are also listed in this Figure.

Anticipated percentage cost changes by equipment subgroups are needed for the development of nominal cost curves in the forecast mode. Cost projections for total equipment categories, as well as for all materials handling and storage equipment in general, are developed for comparative display purposes.

Equipment Categories		Greater through-put	Greater relia-bility	More restric-tive safety require-ments	In-creased stack-ing heights	Control sophis-tication	Im-proved design	More efficient manu-facturing tech-niques	New mate-rials	More efficient instal-lation tech-niques	Advanced electric/ electronic devices and systems	Net change (per-cent)	Sub-group weight-ing factor
Storage Aids	Total	+1	N/A	+5	+2	N/A	-1	-2	0	0	N/A	+5	
Racks		+1	0	+9	+4	N/A	-1	-2	0	-1	N/A	+10	15.01
[illegible]		N.A	N.A	+1	N.A	N.A	0	2	0	0	N.A	+1	[illegible]
Pallets		0	N/A	0	+2	N/A	0	-2	0	N/A	N/A	0	7.51
Storage/Retrieval Machines	Total	+5	+1	+5	+2	+6	-6	-3	0	-1	-5	+6	
Rail mounted -- manual control		+8	-2	-5	-2	+1	-5	-2	0	-1	0	+10	0.12
Rail mounted -- automatic control		+5	+1	+5	+2	+6	-6	-3	0	-1	-1	+6	2.37
Floor mounted -- manual control		+4	+2	+5	+2	+1	-4	-2	0	-1	-1	+6	0.18
Floor mounted -- automatic control		+5	+1	+5	12	16	-6	-3	0	-1	-5	+6	-
Cranes and Hoists	Total	+1	+1	+4	N/A	+2	-2	0	0	-1	0	+5	
Lift Trucks	Total	+1	+2	+3	+1	+2	-2	-1	0	N/A	-1	+9	
Conventional forklift trucks		+1	+2	+3	+3	+2	-2	-1	0	N/A	-1	+9	13.15
Narrow aisle lift trucks		+1	+2	+1	+6	+2	-2	-2	0	N/A	-1	+11	0.22
Walkies		+1	+1	+2	+1	+1	-1	-1	0	N/A	0	+4	0.11
Order pickers		+2	+2	14	+1	+3	-1	0	0	0	-1	+12	1.71
Mobile Horizontal Transport Equipment	Total	+2	+1	+2	N/A	+6	0	-1	0	-1	-1	+8	
Tractor-trailers		+2	+1	+2	N/A	+6	0	-1	0	-1	-1	+8	3.43
[illegible] carriers		+2	+1	+2	N/A	+4	-3	-1	0	-1	0	+6	0.03
Hand trucks		0	0	+1	N/A	N/A	0	-1	0	N/A	N/A	0	0.01
Pallet and skid jacks		+1	0	0	N/A	+1	-1	0	0	N/A	0	+1	0.02
Fixed Path Horizontal Transport Equipment	Total	+10	+5	+8	N/A	+5	-5	-3	0	-1	0	+19	
Conveyors	Total	+4	+6	+9	N/A	+11	-6	-3	-1	-3	-1	+16	
Belt and roller		+1	+3	+10	N/A	+12	-6	-4	-1	-3	-1	+17	9.36
[illegible]		+4	+4	+8	N/A	+10	-6	-2	-1	-2	-2	+11	3.41
Conveyor Peripheral Devices	Total	+12	+5	+9	N/A	+9	-7	-4	0	-3	-2	+19	
Sorters		+14	+6	+10	N/A	+10	-7	-5	0	-3	-2	+21	3.04
[illegible]		+13	+5	+10	N/A	+10	-6	-8	0	-3	-2	+23	0.19
Lifts		+8	5	+10	N/A	+7	-6	-4	0	-3	-1	+16	0.26
Palletizers and depalletizers		+5	+1	+6	N/A	+5	-5	-4	0	-3	-2	+5	0.08
Shrink and stretch wrap machines		+6	+2	+8	N/A	+6	-6	-2	0	-2	-2	+10	0.19
Strapping machines		+8	+4	+9	N/A	+2	-7	-6	0	-1	-3	+6	0.25
Other		+10	+5	+8	N/A	17	-6	-4	0	-3	-2	+15	1.45
Computers and Controllers[a]	Total	0	0	N/A	N/A	+8	-9	-5	-5	-8	N/A	-21	
Intelligence Acquisition Devices	Total	+1	+3	N/A	N/A	+7	-6	-25	-8	-3	N/A	-29	
Keyboards and CRT units		0	+1	N/A	N/A	+6	-3	-22	-8	-4	N/A	-10	0.40
[illegible] and tape readers		0	+2	N/A	N/A	+5	-3	-22	-8	-3	N/A	-28	0.43
[illegible] readers		+4	+5	N/A	N/A	+6	-3	-25	-7	-3	N/A	-23	0.34
Voice [illegible]		0	+5	N/A	N/A	+10	-15	-24	-9	-3	N/A	-36	0.32

N/A -- Not applicable.

[illegible]

[a]See Figure 2-1.

Figure 2-2

Equipment Cost Matrix

(Percent cost increase/decrease, 1976-1986 excluding inflation)

Equipment categories	Systemwide cost[a] (thousands of dollars)	Subgroup weighting factor	Category weighting factor
Storage Aids			
Racks	155,699	38.21	
Bins	83,271	16.25	59.61
Pallets	26,375	5.15	
Storage/Retrieval Machines			
Rail mounted -- manual control	34,329	6.70	
Rail mounted -- automatic control	8,896	1.74	8.44
Floor mounted -- manual control			
Floor mounted -- automatic control			
Cranes and Hoists	106,540	20.80	20.80
Lift Trucks			
Conventional forklift trucks	17,149	3.34	
Narrow-aisle lift trucks	7,303	1.43	4.77
Walkies			
Order pickers			
Mobile Horizontal Transport Equipment			
Tractor-trailers	1,588	0.32	
Burden carriers	3,048	0.59	0.99
Handtrucks			
Pallet and skid jacks	421	0.08	
Fixed Path Horizontal Transport Equipment	3,907	0.76	0.76
Conveyors			
Belt and roller	2,373	0.46	0.46
Overhead			
Conveyors Peripheral Devices			
Sorters	6,229	1.21	
Mergers			
Lifts			
Palletizers and depalletizers			3.31
Shrink and stretch wrap machines	1,392	0.27	
Strapping machines			
Other	9,351	1.83	
Computers and Controllers	197	0.04	0.04
Intelligence Acquisition Devices			
Keyboards and CRT units	1,299	0.25	
Card and tape readers			
Code readers	284	0.06	0.82
Voice encorders	2,615	0.51	
Grand total	512,266	100.00	100.00

[a]From state-of-the-art nominal cost development.

Figure 2-3

Equipment Cost Weighting Factors

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Forecast factors, representing the increase in cost from 1976 to 1986, for each equipment category are developed and summarized in Figure 2-4. For each category, the net percentage change from Figure 2-3 is listed and converted to a change index. For example, a percentage increase of 20 percent equals an index of 1.2, and a percentage decrease of 20 percent equals an index of 0.8.

This change index is adjusted by an inflation factor to develop the forecast factor for each equipment category. Application of this factor to the current (1976) cost of an equipment item in each category produces the anticipated cost of the item in 1986. The composite equipment forecast factor, representing the overall projection factor to be applied to equipment in general, for comparative purposes, is also shown in Figure 2-4. Calculation of the composite factor includes the weighting of each category forecast factor using the individual category weighting factors.

We are forecasting an overall equipment cost increase of 70 percent from 1976 to 1986.

2. Effect of Inflation on Equipment Cost

In this discussion, the term "inflation factor" represents the current value of future dollars. If an equipment item is not expected to increase in cost from 1976 to 1986 <u>except</u> due to inflation, the cost change index would be 1.00. Since inflation is expected to be slightly less than 5 percent annually from 1976 to 1986, the 1986 inflation factor is 1.61. Thus, the example equipment item would cost 61 percent[1] more in 1986 than currently, due only to inflation.

Annual inflation factors from 1976 to 1986, and the corresponding annual composite equipment forecast factors, are listed in Figure 2-5.

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(1) $\frac{1.00 \times 1.61}{100}$ = 61 percent.

	Equipment categories										
	Storage aids	Storage/ re- trieval machines	Cranes and hoists	Lift trucks	Mobile hori- zontal transport equipment	Fixed path hori- zontal transport equipment	Con- veyors	Con- veyor periph- eral devices	Computers and con- trollers	Intel- ligence acqui- sition devices	Total
Net percentage change[a]	+5	+6	+5	+9	+8	+19	+16	+19	-21	-29	
Cost change index[b]	1.05	1.06	1.05	1.09	1.08	1.19	1.16	1.19	0.79	0.71	
Inflation factor[c]	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	
Forecast factor[d]	1.69	1.71	1.69	1.75	1.74	1.92	1.87	1.92	1.27	1.14	
Category weighting factor[e]	59.61	8.44	20.80	4.77	0.99	0.76	0.46	3.31	0.04	0.82	100.0
Composite equipment forecast factor[f]	-	-	-	-	-	-	-	-	-	-	1.70

[a]From Figure 2-2.
[b]Developed from net percentage change. No change = 1.00.
[c]From Figure 2-5.
[d]Change index x inflation factor = Forecast Factor.
[e]From Figure 2-3.
[f] $\sum \left[\text{(Forecast Factor) (Weighting factor for each category)} \right] \div \text{(total of all weighting factors)}$.

Figure 2-4

Equipment Cost Summary

(1986)

Year	Inflation factor[a]	Composite equipment forecast factor
1976	1.00	1.00
1977	1.09	1.17
1978	1.15	1.23
1979	1.21	1.29
1980	1.26	1.35
1981	1.31	1.40
1982	1.37	1.47
1983	1.42	1.52
1984	47	1.57
1985	1.53	1.63
1986	1.61	1.70

[a] Department of Defense Deflators (Outlays), 28 January 1976, Office of the Assistant Secretary of Defense (Controller).

Figure 2-5

Annual Equipment Cost Factors

(1976-1986)

3. Equipment Productivity

Significant increases in the productivity of equipment components are not anticipated over the next ten years.

The reasons for this are threefold. First, equipment suppliers do not feel pressure to increase the productivity of equipment components. Secondly, most conventional equipment components are near their practical physical limit as regards capacity, speed and production rate, and finally, the trend in materials handling system design is to increase productivity through the effective utilization of components in systems rather than to improve the capabilities of individual components.

The latter two reasons are discussed in other sections of this Report. Amplification of the first reason is discussed below.

The majority of equipment suppliers interviewed during the course of our forecast effort recognized that:

- In order to sell equipment components in the future, all equipment price increases, other than those due to inflation, would have to be justified by a combination of: a) a corresponding rise in equipment productivity, b) a corresponding rise in the cost of labor, or c) the absence of a corresponding increase in the productivity of labor.

They further believed that:

- Hourly wage rates would increase faster than the cost of equipment. The information summarized in this Report (Figures 2-5 and 2-6) supports this belief. Based upon our research and available data obtained from the DOD we are forecasting a 90 percent increase in labor rates and a 70 percent increase in equipment costs during the 1976-1986 timeframe.

and that:

- Labor productivity would not increase significantly during the next ten years. There is also other supporting evidence to reinforce this belief. Dr. Peter Drucker, the nationally-known economist, teacher, and author, stated in recent public remarks before the November 1976 Ward Howell Roundtable that, "It would

Year	Annual index values (base year 1975)	Annual index values (base year 1976)
1960	45	42
1961	48	45
1962	49	45
1963	50	47
1964	52	49
1965	55	51
1966	56	52
1967	58	54
1968	60	56
1969	64	60
1970	71	66
1971	76	71
1972	82	76
1973	86	80
1974	92	86
1975	100	93
1976	108	100
1977	116	107
1978	123	114
1979	130	121
1980	138	129
1981	147	136
1982	157	146
1983	167	156
1984	179	166
1985	191	178
1986	204	190

Source: Department of Defense Deflators (Outlays), Civilian Pay Cost Indices, Office of the Assistant Secretary of Defense (Comptroller), 28 January 1976.

Figure 2-6

Civilian Pay Indices

take a wild optimist to assume there has been any improvement in productivity in any of them (nonmanufacturing services) in this century." Dr. Drucker goes on to discuss his pessimism that the social changes required to increase productivity significantly will occur.

In addition, our own experience with a variety of commercial and governmental clients has indicated that warehousing-type labor is becoming less available than in the past because younger people are looking to more "rewarding" career areas, and that the warehouse labor force is aging thus reducing the physical capability to meet performance standards.

Because they believe that labor costs will rise and that labor productivity will not increase, equipment suppliers do not feel an urgent need to emphasize productivity increases in individual units to justify increases in equipment costs.

This conclusion that equipment productivity increases will be insignificant and the associated conclusion that labor productivity will not increase significantly are important inputs to nominal cost curve development. We can feel confident that current equipment capacities and production rates, and existing labor performance standards can be used in the development of future, as well as current state-of-the-art, cost curves, while systems concepts will provide the main thrust to overall productivity improvement.

C. DEVELOPMENT OF EQUIPMENT COST CHANGES

This section is a discussion of the impact of individual cost factors on each of the equipment items insofar as they are applicable, and includes the percentage cost change of each based on the consensus of field interviews and DS/SD internal expertise. Because the field interviews were conducted with an understanding of strict confidence on our part, statements and data contained in the following discussion are not attributed to individual persons or organizations, but represent composite opinions and ideas. The review follows equipment category sequence and the cost change percentages shown are those summarized in Figure 2-2.

1. Storage Aids

a. Racks.

(1) Greater Throughput. More than half of the equipment manufacturers interviewed commented on continual pressure from their customers to provide greater system throughput. About two thirds of those offering the comment said this would be achieved partly through larger and heavier unit loads. The advent of larger and heavier loads will require heavier rack structures and larger pallet openings. Percentage cost change: +1.

(2) Greater Reliability. For conventional heights, the reliability of racks is not an area of expected improvement. Increased tolerances to satisfy the accuracy requirements of automated systems are discussed under increased stacking height below.

(3) More Restrictive Safety Requirements. There are two major safety areas which may have a direct influence on the cost of racks. One is local mandatory application of provisions of the Universal Building Code in major seismic damage risk zones such as California and the Puget Sound Area. Meeting the requirements of the 1976 code can increase the cost as much as 30 percent!

The second is American National Standards Institute (ANSI) Standard B16.1 which specifies structural standards for racks and if adopted by OSHA, can increase rack costs 15 percent to 20 percent, or conversely, can lower rack capacities 15 percent to 20 percent.

These two potential requirements are not necessarily compounding. The Rack Manufacturers' Institute is currently sponsoring an 18-20 month seismic investigation on the West Coast, which might lessen the present stringent requirements; however, it is probable that B16.1 will be adopted. Percentage cost change: +9.

(4) Increased Stacking Height. There is general agreement among both rack manufacturers and stacker crane manufacturers that

the practical height limit of stacker crane systems is 60 feet. While it is feasible to go higher, the cost per pallet position makes such installations uneconomic. For greater heights, rack uprights can no longer be fabricated from roll-formed sections, but must utilize structural steel. The structure of the crane itself becomes substantially more expensive because of the extreme length of its frame members which require bracing for stability.

There is general agreement among lift truck manufacturers that the practical height limit for racks to be used with lift trucks and order pickers is 40 feet.

Rack costs are normally expressed in terms of dollars per pallet position. These costs are influenced by height, design load capacity, load size, and required accuracy of alignment. Alignment becomes more critical as height increases, especially when used with automatic rail-mounted stacker cranes. The number of uprights required also influences cost. Stacker crane systems normally store one pallet wide per rack bay, while floor-running, manually-controlled vehicles usually have enough flexibility to allow two pallets per bay. The following mid-1976 prices will illustrate. All are based on a nominal 10,000 pallet installation utilizing 40- x 48-inch pallets with 3,000-pound loads, excluding freight from point of manufacture:

Rack type	Number of pallets high	Height to top load beam (feet)	Number of pallets per bay	Cost per pallet position (dollars) Mate-riel	Erec-tion	Total
Standard selective	5	22	2	19.50	3.75	23.25
Swing reach	8	40	2	26.30	6.30	32.60
Manual stacker	13	63	1	45.90	12.50	58.40
Automatic stacker	13	63	1	72.05	26.00	98.05

High-rise storage installations are much in vogue. It is obvious that the justification must come from substantial savings in building costs and operational factors to overcome the high rack

cost and the crane costs. The advocates of such systems point out the somewhat intangible benefits of better inventory control and faster access, and quite possibly in manufacturing industries there is real merit in this aspect. Percentage cost change: +4.

(5) Control Sophistication. Is not applicable to static equipment.

(6) Improved Design. Only one of the suppliers interviewed indicated any potential saving through improved design, and that was a general observation. The rack industry is a high-volume business, extremely competitive, and the major companies are staffed with highly competent designers. Percentage cost change: -1.

(7) More Efficient Manufacturing Techniques. As in the case of design, the large producers of racks have had the experience and the volume to have their shops in good order and well equipped. Smaller producers have either followed the lead or have become highly specialized. Percentage cost change: -2.

(8) New Materials. Racks are constructed almost exclusively from roll-formed steel shapes, with the exception of those used for heavy loads. Some racks have been built in Europe from reinforced concrete, and General Foods has one such installation in this country. After a considerable publicity fanfare at the time of construction, it has not been mentioned lately. We are informed that it is unlikely to be tried again, although no reason was given. Percentage cost change: 0.

(9) More Efficient Installation Techniques. None of the suppliers interviewed offered any comment on possible savings through better field installation methods. It is our opinion that there might be some benefits attained, but not of any great magnitude. Large installations are quite well organized, and the competitive prod forces installers to keep their prices within reason. Much of rack work is highly repetitive, which lends itself to systematized effort. Percentage cost change: -1.

(10) Advanced Electrical/Electronic Devices and Systems. Are not applicable to this item.

b. Lins. This discussion is directed to the shelving used for the storage and picking of small parts, manually, from the floor, from ladders, or from order-picker lift trucks. Shelving has been in use for many years and is made in large quantities. It is highly competitive in the marketplace and consequently has been well refined in design, materiels, and erection techniques. For all cost factors the net percentage cost change is: +1.

c. Pallets. Our forecast for pallets reflects the belief of the suppliers interviewed that the pallet will continue as the principal supporting device for unit loads. While some commercial applications are trending toward clamp handling or slip-sheet handling, both in storage and in transportation, it is considered doubtful that such specialized techniques can offer the flexibility needed to handle the variety of package types encountered in large, multifunction operations. It is also believed that the day-to-day working pallet will continue to be made of wood, predominantly hardwood, and that the more exotic types such as wire, steel, aluminum, and plastic will remain too costly for normal warehouse application, with the possible exception of use with storage and retrieval machines, some of which are quite demanding as to the strength and dimensional accuracy of slave pallets required for successful operation.

(1) Greater Throughput. It is unlikely that there will be any increase in unit load sizes and weights to achieve greater throughput due to the large quantities of standard sized pallets currently in use. Percentage cost change: 0.

(2) Greater Reliability. Is not applicable to this type of equipment.

(3) More Restrictive Safety Requirements. There is no anticipated change in pallet design or construction for this cause.

(4) Increased Stacking Height. Normal bulk and racked pallet operations will not be significantly affected by increased stacking heights since superimposed stacked loads are almost invariably limited by the strength of the stored materiel. However, the trend toward greater use of high-rise storage and retrieval machines will increase the quantity of slave pallets in service. These slave pallets normally cost about ten times as much as standard wood pallets. Percentage cost change: +2.

(5) Control Sophistication. Is not applicable.

(6) Improved Design. It is doubtful that there will be any design changes in pallets during the next ten years that will have any significant effect on prices.

(7) More Efficient Manufacturing Techniques. Most wooden pallets are made in small mills in rural areas so as to be close to the lumber sources. We expect that this situation will continue. Most of these mills now use assembly line techniques with jigs and nailing machines. Percentage cost change: -2.

(8) New Materiels. No change in basic warehousing pallets is expected until either the supply of wood is reduced to the point where prices will be high enough to make metal or plastic pallets attractive, or a new materiel, as yet unheralded, comes on the market which will be price competitive and have at least equally suitable characteristics. Neither of these events is expected to occur within the next ten years. Percentage cost change: 0.

(9) More Efficient Installation Techniques. Are not applicable.

(10) Advanced Electrical/Electronic Devices and Systems. Are not applicable.

2. Storage and Retrieval Machines

Large unit load handling installations involving high turnover, and complex scheduling and recordkeeping present attractive opportunities for employment of automatic storage and retrieval systems under full computer control. The number of such installations is currently limited. There are, however, many storage installations of less magnitude which are susceptible to the manually-operated S&R technique both for economic reasons and for the advantages of orderly stock regimentation. For these situations, there are available numerous makes and configurations of storage and retrieval machines, both rail- and floor-mounted, with varying degrees of sophistication. The choice of any application is dependent on the parameters of the individual situation.

a. Rail-Mounted, Manually-Controlled. This discussion covers conventional, manually-controlled storage and retrieval cranes which utilize a shuttle platform to extend one, two or three pallets deep on either side of an aisle to deposit or pick up loads, plus the type of machine which uses a small, low-lift platform with wheels to travel into the rack structure to deposit or pick up loads. This type of machine, having successfully operated with storage depths of 18 pallets, provides a great cost advantage where lot sizes are sufficiently large.

(1) Greater Throughput. Increased throughput may come from three sources: larger unit loads, faster operation, and multiple pallet handling.

Larger unit loads require heavier crane construction and greater lifting capability, and availability of sufficient material to justify larger unit loads.

Faster operation requires control refinement to provide smoother, more rapid acceleration and deceleration. Unless aisles are long, cranes do not reach their maximum speed for any considerable time interval. Load integrity also becomes a factor as speed and acceleration/deceleration increase. The manually-controlled crane offers some advantage here, for the operator can judge how fast any given load can safely be moved.

Double pallet handling offers a considerable opportunity to increase capacity with a relatively small increase in cost. Our survey results indicate that double pallet handling in manually-controlled systems can produce up to a 60 percent gain in units handled per hour. Percentage cost change: +8.

(2) Greater Reliability. No significant cost change is anticipated. Percentage cost change: +2.

(3) More Restrictive Safety Requirements. It is difficult to forecast what OSHA may do in the area of manually-controlled storage and retrieval machines. Most suppliers interviewed believed, however, that more stringent requirements would be effected. Percentage cost change: +5.

(4) Increased Stacking Heights. We believe it unlikely that the maximum height of manual systems will exceed the current 60-foot limitation. However, since there are a number of current

installations in the 20- to 40-foot range, the number of 60-foot installations will grow. While such an increase raises the storage capacity, it does not increase the throughput. The net effect may be the converse, since horizontal travel is faster than vertical. Percentage cost change: +2.

(5) Control Sophistication. A manual system by its name implies a simplicity of control and, to remain competitive, it must stay that way. Percentage cost change: +1.

(6) Improved Design. Although manned S&R machines have been in use for a number of years, the normal evolutionary upgrading is still in process and will continue for several more years. This is due partly to the number of suppliers in a limited market. None of them does enough of a volume business to concentrate its individual design efforts. Also, it should be noted that, with a few exceptions, the current producers are multiproduct and naturally focus their design effort in those areas wherein best profit possibilites exist. Percentage cost change: -5.

(7) More Efficient Manufacturing Techniques. As a corollary to design improvements, there will be a trend toward standardization of components and generally better assembly techniques. No "standard" design is expected because of the varied customer applications. Percentage cost change: -2.

(8) New Materiels. No startling advance or change in materiels is expected.

(9) More Efficient Installation Techniques. Techniques of installing and leveling rails are generally well known, as are the problems incident to providing power sources. Percentage cost change: -1.

(10) Advanced Electrical/Electronic Devices and Systems. Two possible areas are open to the introduction of new electrical/electronic devices. One is improved control of acceleration and deceleration using solid-state elements, and the other is provision of on-board intelligence for upgrading inventory information and for programming the order of work. Both are expensive and so will be used only in limited applications where factors other than economics can justify their incorporation. Percentage cost change: 0.

b. Rail-Mounted Automatic. This equipment subgroup includes the broad field of automatic storage and retrieval machines, including the "semiautomatic" type, as long as the principal control does not require an on-board person to control the movements of the machine. Most ministackers fall within this classification.

(1) Greater Throughput. Greater throughput can be achieved through the handling of larger unit loads and faster operation. The capability to handle larger unit loads requires greater lifting capacity and heavier construction of equipment.

Attainment of higher speeds requires stable loads and refined control systems. Because these units are unmanned, soft acceleration and deceleration must result from advanced controls. Percentage cost change: +5.

(2) Greater Reliability. Mechanically, automatic storage and retrieval machines have established a fine record for reliability. There have been a few electrical problems, but most of the difficulties involve computer software problems. The user is usually denied the full use of his equipment for extended time periods. Vendors speak of building up program libraries, but normally each system is too unique to utilize a canned program. Percentage cost change: +3.

(3) More Restrictive Safety Requirements. Although these units are unmanned and unattended vehicles, and usually operate in an uninhabited environment, those surveyed believe this cost factor will have significant impact on future costs. Percentage cost change: +5.

(4) Increased Stacking Heights. Most of the interviewees believed a range of practical limiting heights for these units to be 55 to 80 feet, with the majority considering 60 feet as the optimum. As noted above, the cost of racks increases sharply as rack heights go above 20 feet, and the increase for automatic installations is even more pronounced. The cost of cranes does not change so dramatically. Thus, the cost variable is most affected by structural uprights and additional controls. Percentage cost change: +2.

(5) Control Sophistication. This is an area where users tend to get carried away and specify more capability than the application justifies because, with computers, control capabilities are available to do all sorts of things. Some control improvements may be justified under the heading of reliability, but a great deal falls into the "nice-to-have" category. By way of example, the following tabulation was prepared by one of the leading AS&R manufacturers:

	Level of sophistication					
	Computer directed	Simple closed loop	Real-time systems	Error reco-very	Dis-tributive networks	Re-dele-gation capa-bility
Hardware cost	Base X	1-3X	5-10X	10-30X	30-60X	50-100X
Software cost	Base Y	2-3Y	5-10Y	10-20Y	10-30Y	20-80Y
Software as a % of total initial cost	40-50	40-60	50	40-50	30-50	30-40

It would be sheer speculation to predict what the attitude of the DOD might be. Percentage cost change: +6.

(6) Improved Design. This type of equipment is still in the evolutionary stage, and suppliers are expected to continue to make design improvements for performance, reliability, and cost improvement. Percentage cost change: -6.

(7) More Efficient Manufacturing Techniques. Some cost reduction is anticipated through standardization of components which spread the design costs over more units and which simplify shop operations. The extent of such standardization is limited because of the variations between applications. Percentage cost change: -3.

(8) New Materials. No change is anticipated.

(9) More Efficient Installation Techniques. The field erection of cranes is a well-understood technique. The testing phase, always a problem with computerized systems, should show some reductions as installers become more adept at trouble-shooting systems. Percentage cost change: -1.

(10) Advanced Electrical/Electronic Devices and Systems. Many of the systems now in operation or on order are equipped with state-of-the-art controls employing the latest developments in microprocessors and minicomputers all tied to a master central processing unit. This trend toward the use of small, special-purpose electronic devices has moved in rapidly and with apparent great success. The cost trend, especially for the microprocessors, is down, even though the accompanying software may be somewhat more complex and expensive. Percentage cost change: -5.

c. Floor-Mounted Manual. The equipment covered herein is of fairly recent development. So far as we have been able to determine, only four U.S. companies have this sort of equipment in actual operation with a fifth in the prototype stage. The four in operation are modifications of narrow-aisle lift trucks, while the prototype represents a completely original design. There is one British unit that has been in use for about 15 years, but with few installations in the U.S. This, too, is a unique design. In our opinion, there is a considerable future for this type of unit load handler with its ability to operate in narrow aisles and to travel at will between and away from aisles.

(1) Greater Throughput. The capacities and speeds, both travel and lift, of the swing reach lift trucks now on the market are at about the limit of load stability, which would indicate that no more throughput can be expected from vehicles of this type. However, mobile stacker cranes can provide increased throughput by using tandem shuttle platforms which should give them an estimated 50 percent handling rate increase. Percentage cost change: +4.

(2) Greater Reliability. Manual, floor-mounted equipment has not been in service long enough to be considered adequately use-tested. Percentage cost change: +2.

(3) More Restrictive Safety Requirements. Although presently manufactured units meet all established requirements, additional restrictions are expected. Percentage cost change: +5.

(4) Increased Stacking Heights. The current limit of 40 feet is considered the maximum practical with floor running equipment. Percentage cost change: +2.

(5) Control Sophistication. No major changes are anticipated in manually-operated machines. Percentage cost change: +1.

(6) Improved Design. Basic components of currently used equipment are of standardized design. Percentage cost change: -4.

(7) More Efficient Manufacturing Techniques. The equipment now on the market is produced by experienced companies with proven techniques of manufacturing. Percentage cost change: -2.

(8) New Materiels. No change is anticipated.

(9) More Efficient Installation Techniques. This type of machine requires aisle guidance, mechanical and/or electronic. The application of such guidance is subject to improvement. Percentage cost change: -1.

(10) Advanced Electrical/Electronic Devices and Systems. Floor-mounted, manually-operated S&R equipment is battery operated and utilizes Silicon Controlled Rectifier (SCR) speed controls of the most advanced type. The only potential for improvement is in the batteries themselves. This aspect will be discussed in more detail in the lift truck review below. Percentage cost change: -1.

d. Floor-Mounted, Automatic. To the best of our knowledge, this version of a storage and retrieval machine has never been marketed. However, basically similar equipment is available in the form of an order picker with completely automatic guidance, travel, and lift functions.

During the course of interviews with equipment manufacturers, two highly respected firms stated that the needed technology is available and floor-mounted, automatic machines are considered mechanically and electronically feasible. As yet, there is no identifiable market for such equipment now, and no selling price has as yet been established. Since respondents to our questionnaire were unanimous in their cost projections, we are including this equipment subgroup in the forecast, using the same percentage cost changes as for automatic rail-mounted units, in the event that automatic, floor-mounted equipment becomes available.

3. Cranes and Hoists

While this is a broad category and has wide application on DOD installations, the incidence within the current supply system is, for the most part, restricted to a few types; mobile cranes employed in outside storage functions, and bridge cranes used to handle very heavy machinery. This category will be treated primarily as it relates to heavy lift equipment.

a. Greater Throughput. Because of the limited movement and the specialized nature of the items handled, no major change is expected. Percentage cost change: +1.

b. Greater Reliability. By virtue of having been in use for many years, reliability is now well established and not expected to produce any significant changes. Percentage cost change: +1.

c. More Restrictive Safety Requirements. The American National Standards Committee, B-30; Safety Standards for Cableways, Cranes, Derricks, Hoists, Hooks, Jacks and Slings, is currently reviewing the following standards which affect depot storage equipment:

B 30.5 Mobile and Locomotive Cranes
B 30.17 Overhead and Gantry Cranes
B 30.16 Overhead Hoists.

The proposed changes are expected to have some cost impact. Percentage cost change: +4.

d. Increased Stacking Heights. Are not applicable.

e. Control Sophistication. There are currently on the market new crane speed control devices which utilize solid-state elements to achieve closer control than the conventional devices. Percentage cost change: +2.

f. Improved Design. No major changes are anticipated. Percentage cost change: -2.

g. More Efficient Manufacturing Techniques. The manufacturers who produce this type of equipment have been in the business for many years. No changes can be expected that will influence costs.

h. New Materiels. None expected.

i. More Efficient Installation Techniques. Because installation costs for cranes are significant, there is room for improvement. Percentage cost change: -1.

j. Advanced Electrical/Electronic Devices and Systems. No change is expected.

4. Lift Trucks

As a category, lift trucks probably are the most versatile and widely used type of handling equipment in storage and supply operations in both the public and private sectors. The entire development of the lift truck has taken place within the last 40 years and, while the industry has become stabilized, new ideas and applications are still coming on the market. Until the mid-1950's, counterbalanced rider trucks were the standard work-horses, supplemented by walkies for specific applications. Since the 1950's, narrow-aisle equipment has become increasingly important and now represents the largest portion of new trucks sold. Order pickers have been taken out of the narrow-aisle group and are treated separately because of the specialized function they perform and the automation potential involved.

a. Conventional Forklift Trucks. The counterbalanced rider-type forklift truck, both battery and internal combustion engine powered, seems to have reached a performance plateau after undergoing a series of improvements over the past several years. The following comments on cost factors reflect this situation.

(1) Greater Throughput. Throughput for forklift trucks is a function of capacity, travel speed, and lift speed. For normal supply operations, lift trucks are available in any desired capacity, and present trucks are adequate to handle standard unit loads. Current standard battery-operated trucks offer travel speeds of 10-11 m.p.h. and lift speeds (loaded) of up to 120 f.p.m. Since higher speeds become hazardous, the expected throughput increase potential is small. Percentage cost change: +3.

(2) Greater Reliability. Some manufacturers of battery-operated trucks are now offering diagnostic plug-in units to improve preventive maintenance. For large operations this is an immediate forward step and is expected to come into general use. At present it represents an investment of about 15 percent of the average truck price, and one unit can service several trucks. Percentage cost change: +2.

(3) More Restrictive Safety Requirements. Forklift trucks are under strict OSHA standards which have been in effect for several years. We know of no pressures to make these more restrictive. There is a chance that the industry will introduce four-wheel brakes and, if so, will probably absorb most of the cost. Percentage cost change: +3.

(4) Increased Stacking Heights. Lift heights are now available to 300 inches. It is unlikely that counterbalanced trucks will go much higher for reasons of stability, which reduces the load capacity. Trucks are derated 5 percent per foot above 156 inches, so that at 300 inches, a given truck can only be rated for 40 percent of its basic capacity. Percentage cost change: +3.

(5) Control Sophistication. All the leading manufacturers now provide SCR control as standard equipment. Only minor control refinements are expected. Percentage cost change: +2.

(6) Improved Design. Design of conventional units has become so standardized that significant improvements are not foreseen. Percentage cost change: -2.

(7) More Efficient Manufacturing Techniques. Lift trucks are assembly line products and only minor savings, which would be reflected in selling price, are expected. Percentage cost change: -1.

(8) New Materiels. None anticipated.

(9) More Efficient Installation Techniques. Are not applicable.

(10) Advanced Electrical/Electronic Devices and Systems. Such devices are not normally used with standard lift trucks. Percentage cost change: -1.

b. Narrow-Aisle Lift Trucks. This type of truck has recently undergone some rapid and radical changes, and more are expected.

(1) General Throughput. Capacities are adequate in presently available equipment, so any increases will have to come from higher travel and lift speeds. Percentage cost change: +3.

(2) Greater Reliability. Diagnostic devices to improve preventive maintenance techniques are available and will be employed to a continuously greater extent to unearth problems before they cause equipment failure. Mechanically most standard makes are adequate as to reliability, but some lower-priced trucks are not capable of withstanding continuous operation.

New battery types are expected to come into general use within the next five years. These will be permanently sealed, able to withstand fast charge and discharge rates, and have equivalent capacities and costs to today's lead-acid batteries. They are now available in capacities to 20 ampere hours. Percentage cost change: +2.

(3) More Restrictive Safety Requirements. No major new requirements are anticipated. Percentage cost change: +3.

(4) Increased Stacking Heights. All the leading suppliers now offer three stage uprights with lifts in the 16-foot range as standard items. Several companies have produced lifts in the 22-foot range, both in straddle and reach configurations, and one manufacturer offers a side loader with 30 feet of lift. Swing-reach trucks, which we have chosen to classify as storage and retrieval devices, are available with lifts to 40 feet. Due to the size and weight considerations, straddle or reach trucks built with such extreme lifts add significantly to the cost. For example, a 4,000-pound capacity side loader with batteries and charger and 20-foot lift costs about $24,000. With 30-foot lift it costs $45,000. Percentage cost change: +6.

(5) Control Sophistication. Most standard narrow-aisle trucks now have SCR speed control as standard equipment. Since this type of truck is not suited for automatic guidance or route programming, further control sophistication of a significant degree is unlikely. Percentage cost change: +2.

(6) Improved Design. Design changes and improvements are expected to continue in narrow-aisle equipment, although not on as large a scale as in the last five or six years. Percentage cost change: -2.

(7) More Efficient Manufacturing Techniques. Because rapid developments and many design innovations have taken place in a limited production environment, a degree of design standardization can be expected. Percentage cost change: -2.

(8) New Materiels. No change expected.

(9) More Efficient Installation Techniques. Are not applicable.

(10) Advanced Electrical/Electronic Devices and Systems. Significant cost impact is not expected from this source. This equipment is not readily adaptable to programming. Percentage cost change: -1.

c. Walkies. Walkie-type trucks have always found application for low-volume operations, partly because of simplicity of control and partly because of low initial cost. They are slower than rider equipment since they must travel at walking speed, and lift speeds have been low to hold down the battery capacity required. In the last few years there has been a substantial increase in sales of these trucks, particularly for general purpose use in shipping and receiving areas where operation is intermittent, and it is not desirable to assign a full-time operator. There has also been interest in heavy load capability where the number of movements is low but power equipment is necessary.

(1) Greater Throughput. Heavier load ratings are on the increase and capacities of 6,000 and 8,000 pounds are commonly available. Some special trucks go even higher. Speeds can be expected to increase, although to a limited degree because of basic drive-unit configuration. Percentage cost change: +1.

(2) Greater Reliability. The basic walkie design has been around for nearly 40 years, and all the reputable manufacturers now have their problems fairly well eliminated. We do not expect any major cost penalties from this source. Percentage cost change: +1.

(3) More Restrictive Safety Requirements. No major restrictions are anticipated. Percentage cost change: +2.

(4) Increased Stacking Heights. The option for increased lift is now available on walkie trucks. Straddle stackers with a 250-inch lift have been made, and counterbalanced trucks with lifts of 217 inches have been sold. Although these are exceptions -- the normal high lift limit is about 196 inches -- it is expected that more high lift trucks will be used. Percentage cost change: +1.

(5) Control Sophistication. SCR speed control is offered as an option for about 10 percent of the truck cost. This is a desirable option on high lift trucks. Percentage cost change: +1.

(6) Improved Design. Design changes are expected to be primarily in the area of new attachment capabilities, with little change in basic drive unit and chassis. Percentage cost change: -1.

(7) More Efficient Manufacturing Techniques. This type of equipment is well standardized in basic components, with reasonable production quantities, so little change is expected. Percentage cost change: -1.

(8) New Materiels. No changes are anticipated.

(9) More Efficient Installation Techniques. Are not applicable.

(10) Advanced Electrical/Electronic Devices and Systems. Walkie trucks are not generally adaptable to electronic gadgetry.

d. Order Pickers. The order picker is essentially a modification of the narrow-aisle lift truck. Remote lifting and lowering controls have been used on standard lift trucks for over 30 years. These generally involved the operator positioning his truck from the driver's seat, putting a pallet on the forks, and standing on the pallet while he caused it to go to the desired work height.

This was a slow and somewhat hazardous procedure. It was not until the narrow-aisle truck had come into general use that the idea evolved to place the operator on the fork carriage with a full set of driving controls. The first such trucks had controls for both normal and on-carriage operation. These are still on the market.

Today the majority of order pickers are provided only with controls on the elevating carriage. Order pickers can and have been equipped with a variety of electronic items which provide steering guidance, travel control, lift control, order picking instructions and documentation, and inventory record input. These features can also be obtained in varying combinations. This type of equipment offers great flexibility for small item storage and handling, and offers direct competition to the ministacker. It is not readily adaptable to unit load handling and not well suited to case picking.

(1) Greater Throughput. Anticipated improved throughput, as a result of greater loads or faster speeds, can only be considered marginal for this type of equipment which, as presently marketed, is approaching the limit for safe operation. Percentage cost change: +2.

(2) Greater Reliability. There will be increased utilization of plug-in diagnostic units for detection of incipient problems before they become the cause of equipment failure on the job. Percentage cost change: +2.

(3) More Restrictive Safety Requirements. Other than a possible height restriction discussed below, we foresee nothing which will modify or tighten OSHA requirements for order-picker-type trucks. However, not all manufacturers provide, as standard equipment, a tether line and pallet or cart clamp, both of which are considered essential. Percentage cost change: +4.

(4) Increased Stacking Heights. Opinion is divided among persons interviewed concerning lift height potential of order-picker trucks. Several manufacturers now offer a 20-foot lift in a triple stage upright as standard, and 22 feet is not unusual. Some believe it possible to go as high as 40 feet. Others take the view, that with OSHA restrictions, the practical limit is in the vicinity of 20 feet. Percentage cost change: +3.

(5) Control Sophistication. Of all the types of lift equipment on the market, the order picker has had the most elaborate and sophisticated application of controls.

Some manufacturers offer power steering as standard equipment, some as an extra option, and some cannot provide it. The average extra cost for this feature is about 6 percent of the base cost.

All manufacturers charge extra for side guide rollers, used with mechanical aisle guidance, with the average cost addition about 2 percent of the chassis price. The alternative is electronic guidance, usually employing a wire installed in a slot in the floor with an impressed frequency, which is sensed by a pickup unit on the truck. This feature provides very accurate steering control.

On-board electronics alone may add 40-50 percent to the cost of each truck.

At least three manufacturers offer automatic travel and lift controls under programmed direction. A typical truck with fully-automated controls costs about $75,000, or about seven times the basic truck cost. The percentage cost change of +3 for this cost factor represents a mix of trucks with varying degrees of control sophistication.

(6) Improved Design. Order pickers are considered still developmental with pricing based on standardized basic components, but including some features requiring limited production. Percentage cost change: -1.

(7) More Efficient Manufacturing Techniques. No change is anticipated.

(8) New Materiels. No change is anticipaged.

(9) More Efficient Installation Techniques. For guided systems the guide wire must be installed. There has been enough experience in this procedure to have a standard operation, and generally agreed price for straight wire is $6 to $7 per linear foot. No improvements are expected.

(10) Advanced Electrical/Electronic Devices and Systems. A variety of electronic gear for application to order pickers is now available, and more is anticipated.

In addition to controlling the movement of the vehicle, stock information can be included. A tape with an entire day's work can be read and can furnish picking documents as the work

progresses. Also, instruction can come from a control process computer via the guide wire or by radio. The number of such installations will be limited, and some interviewees suggested that as long as there is an operator on board, automated truck movement control is unnecessary. Percentage cost increase: -1.

5. Mobile Horizontal Transport Equipment

This type of equipment employs many of the basic components of lift trucks and is manufactured largely by the same companies. However, it serves a different purpose in that it is used for movement between locations rather than for storage.

a. Tractor-Trailers. Tractors are normally utilized for light traffic over extended distances (beyond the economic distance for lift truck travel).

(1) Greater Throughput. Significant throughput increases are not anticipated since this equipment is at its best in light traffic situations. There is potential for increased speeds. Percentage cost change: +2.

(2) Greater Reliability. Not much development is expected in this area. Tractors, both manned and driverless, have been around long enough to be fully debugged. Percentage cost change: +1.

(3) More Restrictive Safety Requirements. No major changes are expected. Percentage cost change: +2.

(4) Increased Stacking Heights. Are not applicable.

(5) Control Sophistication. There will be increased emphasis on more involved controls for driverless tractors, and for carts. There are existing systems which interface directly with stacker cranes under the control of the same computer, and which automatically load and unload trailer carts. One such system uses power from the tractor battery to operate powered roller on the cart bed. There also are systems which switch and provide automatic blocking for multiple tractors on one guidance loop. Percentage cost change: +6.

(6) Improved Design. No change is anticipated in manually-operated tractors and trailers, but there is still room for improvements within the driverless category. Further mechanical development to accommodate more sophisticated controls and some not related to controls are predicted, Percentage cost change: 0.

(7) More Efficient Manufacturing Techniques. As new designs become standardized, some minor reductions in manufacturing costs can be expected. Percentage cost change: -1.

(8) New Materials. None is expected.

(9) More Efficient Installation Techniques. Only minor improvements are expected in installing guidance and control wires. Percentage cost change: -1.

(10) Advanced Electrical/Electronic Devices and Systems. On-board electronics for intelligence and communication beyond the vehicle controls are available. These will have a minor impact on the cost of the complete subgroup. Percentage cost change: -1.

b. Burden Carriers. Individually powered burden carriers, either internal combustion engine or battery-powered, have been in use for many years in supply installations and freight terminals. They are normally used as supplemental vehicles for emergency orders and similar duties.

About ten years ago, a wire-guided vehicle was put on the market for hospital use. Five of the manufacturers interviewed are working on the development of such vehicles, including three who are not in the vehicle business now. One plans to offer fully automatic loading and unloading. The rationale is that such a vehicle can be a substitute for the towline and that it offers some real advantages for use in hazardous and high security areas.

(1) Greater Throughput. Since burden carriers are essentially low-volume vehicles, greater throughput is not an important factor. Percentage cost change: +2.

(2) Greater Reliability. Existing installations considered quite reliable. Percentage cost change: +1.

(3) More Restrictive Safety Requirements. No major changes are expected. Percentage cost change: +2.

(4) Increased Stacking Heights. Are not applicable.

(5) Control Sophistication. Existing guided carriers have very sophisticated controls, such as signalling devices and the ability to automatically travel on elevators. With the advent of automatic loading and unloading, further cost increases may be expected. Percentage cost change: +4.

(6) Improved Design. If this becomes an actively competitive item, there will be some cost savings. Percentage cost change: -1.

(7) More Efficient Manufacturing Techniques. No major changes are expected. Percentage cost change: -1.

(8) New Materiels. Nothing new is expected.

(9) More Efficient Installation Techniques. Improvements are expected in wire-guided systems only. Percentage cost change: -1.

(10) Advanced Electrical/Electronic Devices and Systems. No changes are expected.

c. Handtrucks. No significant new developments concerning handtrucks are expected. The net percentage cost change considering all cost factors is 0.

d. Pallet and Skid Jacks. The pallet or skid jack is a basic device for horizontal movement of unit loads which incorporates its own means of picking up and putting down the load. This equipment subgroup has been in service for many years. Innovations are currently being introduced which offer interesting opportunities for broadening the usefulness of palletjacks.

(1) Greater Throughput. For many years the standard palletjack was built for 4,000-pound load capacity. This capacity was the load limit of the small load wheels in the forks. These trucks are now available from most manufacturers in 6,000-pound capacity, and specials have been made for 8,000 pounds. Speeds have been increased, in walk or ride models, up to 5.5 to 6 m.p.h., and in 36-volt rider models to 9 m.p.h. The latter is subject to frequent load wheel failure. Jacks for handling two pallets in tandem have been available for several years. They are now available with four forks for handling a pair of pallets in tandem, and for performing at least one truckloading/unloading operation. This arrangement can be double-tiered to allow the jack to move eight pallets per trip. Percentage cost change: +1.

(2) Greater Reliability. Palletjacks have been in service long enough and are sufficiently competitive to have overcome most maintenance problems except in the durability of the load wheels on

heavier models. This is constantly under investigation. If a solution is found, it will no doubt be furnished at no additional cost, for competitive reasons.

(3) More Restrictive Safety Requirements. None is anticipated.

(4) Increased Stacking Heights. Are not applicable.

(5) Control Sophistication. In the past, the standard speed control on palletjacks was a two-speed relay and resistor. Now most suppliers offer three-speed as standard, and most offer SCR as an option. Percentage cost change: +1.

(6) Improved Design. No significant changes are expected. Most new good quality jacks now are available with six-inch lift instead of four to make truckloading easier. Percentage cost change: -1.

(7) More Efficient Manufacturing Techniques. These are production line items. No appreciable savings which might be passed on to customers are expected.

(8) New Materiels. Other than new load wheel composition, no change is expected, and there should be no effect on cost.

(9) More Efficient Installation Techniques. Are not applicable.

(10) Advanced Electrical/Electronic Devices and Systems. None is anticipated.

6. Fixed Path Horizontal Transport Equipment.

The towline is a proven, reliable means of moving materiel in large quantities over a fixed path, for distributing automatically to multiple destinations, and for providing short-term storage capability. Major drawbacks are the high cost of changing routes, the amount of floor area which must be dedicated to the travel path, and the necessity for keeping this path clear of standing objects at all times.

The towline is essentially a continuous chain conveyor with provision for towing carts. The chain may be overhead, which requires a mast or towing yoke on the cart and a superstructure to carry the chain, or it may be in the floor, which requires a drop-pin on the cart and a trench to accommodate the chain.

a. Greater Throughput. Towline capacity may be increased by larger loads, faster speeds, and closer cart spacing. Each has disadvantages. Larger loads require more floor space for travel path, spurs, and parking, plus additional effort for off-line manipulation.

Normal speed is 60 f.p.m. Higher speeds cause dangerous starting shocks and, in the case of push-off spurs, excessive impact shocks. This can be partially offset by installing hydraulically-dampened spring-loaded shock absorbers on the tow pins. Maximum attainable speed is about 120 f.p.m.

Closer cart spacing creates problems for cross traffic. Only large-volume installations generate enough traffic density to justify any of these capacity increasing measures. Percentage cost change: +10.

b. Greater Reliability. With the exception of switching control problems, towlines have established a reputation of being one of the most reliable pieces of materials handling equipment. No major changes are envisioned. Percentage cost change: +5.

c. More Restrictive Safety Requirements. Most systems do not now make provision for automatic pin release in event an obstruction is encountered. Early safety releases were not reliable, were easily damaged, and expensive. When used in conjunction with a push-off system, they are also very cumbersome. To date, OSHA has not required automatic pin release; however, more restrictive safety measures are foreseen. Percentage cost change: +8.

d. Increased Stacking Heights. Are not applicable.

e. Control Sophistication. Towline controls involve two functions -- drive, and switching. Since the chains are driven by motors, motor control circuits are provided with door interlocks, emergency stop pushbuttons, etc., and with quick-acting current relays to shut the system down in case of jams. These controls are standard, and no changes are foreseen.

Switching controls are available in several types and are still in a state of change and improvement. Mechanical probes are no longer available. Magnetic probes passing between pairs of reed switches work well as long as the magnets maintain their strength and alignment. Radio frequency devices matched with shift register analogs have also been used. The current trend is toward photo-sensors set in the floor with reflective elements mounted on the carts. Percentage cost change: +5.

f. <u>Improved Design</u>. The in-floor towline evolved from the standard chain and trolley conveyor to the sliding chain. There is now available a new light-duty type which uses a sliding side finger chain. This arrangement locates the drive unit above the floor at a considerable saving. We anticipate continuing design advances in this area. Percentage cost change: -5.

g. <u>More Efficient Manufacturing Techniques</u>. Suppliers surveyed expect to reduce costs through manufacturing improvements. Percentage cost change: -3.

h. <u>New Materiels</u>. It is unlikely that there will be any appreciable changes in materiels.

i. <u>More Efficient Installation Techniques</u>. Field installation is still somewhat crude and improvement potential exists. Percentage cost change: -1.

j. <u>Advanced Electrical/Electronic Devices and Systems</u>. Numerous attempts have been made to computerize towcart system controls using shift registers, matrix boards, mechanical analogs, etc., with only moderate success. Past failures have been partially due to electromechanical problems and partially to personnel problems. It only requires the addition or deletion of one cart in a prohibited zone of the track to disrupt an entire program. The most successful practical approach is still escort coding on each cart, read at every switching point. We see no growth in computerized systems except in highly specialized applications such as operations in hazardous or security areas.

7. <u>Conveyors</u>

Conveyors are the most widely used means of moving materiels over fixed paths. They are made in a wide variety of types and configurations depending on what is to be handled and at what rate. Their purpose is primarily one of movement, since they must be loaded and

unloaded by people or other devices. The load/unload function generally establishes the capacity limit. There are two principal categories of conveyors -- bulk, and unit handling. This discussion is confined to unit handling.

We have separated unit handling conveyors into two functional types: one in which the materiel to be moved on the conveying surface, generally referred to as belt and roller conveyors; the other in which the materiel is suspended from an overhead series of hooks or platforms, generally called trolley conveyors.

a. Belt and Roller. Belt and roller conveyors are among the oldest of the materials handling mechanisms on the market. They are built by many firms with wide experience and good reputation. All of the conveyor manufacturers interviewed predict a big future for their product including technical changes to improve performance and reliability. A myriad of new, sophisticated peripheral devices, some with advanced computerized controls, and the potential of integration into major systems, are believed to be major elements in the future of conveyors.

(1) Greater Throughput. The handling capacity of conveyors will be increased primarily by higher speeds, which means use of different and more precise components. It also means that methods of loading and unloading, and package integrity, will have to be improved. Percentage cost change: +3.

(2) Greater Reliability. All persons interviewed commented on the importance of improving reliability through better engineering and the use of more precise components. Percentage cost change: +7.

(3) More Restrictive Safety Requirements. The effect of this factor depends to a large extent on what action OSHA will take. ANSI standard B20.1 was issued during the summer of 1976 under the aegis of ASME. This is a consensus standard which may or may not be adopted by OSHA. As it is written, there is very little in it which would cause reputable conveyor companies much additional expense, considering present conveyor performance characteristics. Higher speeds will necessitate a design change in bearings of the carrying rollers to keep noise levels within acceptable limits. Percentage cost change: +10.

(4) Increased Stacking Heights. Are not applicable.

(5) Control Sophistication. Many new devices and techniques for conveyor control are available and will be reviewed in subsequent paragraphs. This discussion is intended to explore the trend toward the application of these new devices and systems to accomplish more than conventional controls, particularly in the recordkeeping area. Because the capability now exists, it is frequently utilized without full economic justification. The end result is an overall cost higher than it would have been had the original level of sophistication been maintained. Percentage cost change: +12.

(6) Improved Design. All the conveyor manufacturers surveyed stated that they expect design improvements for varying reasons including: greater reliability, higher speeds, better zero-pressure designs, cheaper live-roller conveyors of the longitudinal shaft drive type, and more special product handling. Percentage cost change: -6.

(7) More Efficient Manufacturing Techniques. There will be more manufacturing of standard conveyor items for stock, which should reduce prices and make for faster deliveries. There will be better bearings and better bearing installation techniques. Percentage cost change: -4.

(8) New Materiels. Quicker, more durable bearings made from new materiels and fibreglass frames are included in the forecast for conveyors. Percentage cost change: -1.

(9) More Efficient Installation Techniques. As the labor rates for field installers, particularly millwrights and electricians, increase and as control circuitry becomes more complex, new, less expensive installation techniques must be achieved. There will be an increase in the multiplexing of control circuits to reduce conduit and wire runs. Percentage cost change: -3.

(10) Advanced Electrical/Electronic Devices and Systems. Conveyor systems must be custom-fitted to each installation using standardized components. Since they are capable of moving a variety of individual items over several paths, conveyors are amenable to the application of advanced electrical and electronic devices and systems. All suppliers interviewed were unanimous on this point. It was stated that any control system involving over $1,000 in relays should be converted to use programmable controllers, minicomputers or microprocessors.

Code scanning or voice encoding for identification, counting, and sorting control will be standard for large systems. Limit switches will be superseded by proximity switches and all photo-sensors will use Light Emitting Diodes (LEDs) as light sources. The cost of these electronic devices is decreasing and will continue to do so. Percentage cost change: -1.

b. Overhead. Overhead conveyors find their principal application in manufacturing operations. There are also some installations in supply establishments of the DOD. In discussing conveying equipment with suppliers, the information received was limited and can be summarized in a few sentences. Chain conveyors, now limited to about 60 f.p.m., will be increased somewhat in speed and will cost more because of the speed. Open track trolley conveyors within reaching height of the floor will increase in cost to cover the extra guarding required by OSHA. The percentage cost changes for each cost factor generally follow those for belt and roller conveyors. Net percentage cost change: +13.

8. Conveyor Peripheral Devices

As conveyors have developed into complex systems, the conveyor industry has been called upon to develop auxiliary devices to complete the job requisites. Much of this development has involved machine design and machinery manufacture of a considerably more precise nature than for conveyors themselves. As one leading manufacturer put it, "The cost of conveyors will come down as new materiels and designs are introduced, but the systems costs, due to the many ancillary devices involved, will more than double over the next ten years". We have included some of these devices in this forecast, most of which are in use today and all of which might be used in DOD supply operations. Anticipated percentage cost changes resulting from each cost factor are shown for sorters only. For other computer peripherals, only the net percentage cost change is given.

a. Sorters. Sorting equipment has made rapid strides in the last ten years and has probably reached a plateau of development insofar as speed is concerned. Sorting is an essential adjunct to batch-picking, and scanners have made accurate control possible.

(1) Greater Throughput. Much of the development effort has been directed at increasing throughput. The highest single

complex, capacity rate, we have knowledge of for sorting packages of up to 34"x20"x20" with a maximum weight of 70 pounds, is theoretically 50,000 pieces per hour with a maximum number of sorts of 1,000. It has been tested in prototype only, and costs are reported to be equivalent to those of tilt-tray units. The practical sort rate is in the 35,000-40,000 pieces per hour range. Other representative sorting rates, now in regular operation are:

	Per minute
Pop-up chain for pallet sorting	4 pallets
Blade diverter	30 pieces
Pop-up roller	40-50 pieces
Push-off	60 pieces
Heavy-duty tilt-tray (200 pounds)	60 pieces
Tilt-tray (parcel)	200 pieces
Tilt-slat	200 pieces
Pop-up wheel	200 pieces

The tilt-tray is the most widely used. The present speed limit is about 400 f.p.m. This may go to 500 f.p.m., beyond which loads may tend to blow off the trays. Mechanical refinements needed to attain this speed increase will increase costs. Percentage cost change: +14.

(2) Greater Reliability. Sorters now in use have undergone rather intense development and are the product of good engineering talent. It is interesting to note that with minor exceptions, sorters on the market were not developed by conveyor companies. Additional refinements to improve reliability are expected. Percentage cost change: +6.

(3) More Restrictive Safety Requirements. Changes such as reducing the noise level in the pop-up wheel conveyor which operates in a high-speed roller bed are expected. Percentage cost change: +10.

(4) Increased Stacking Heights. Are not applicable.

(5) Control Sophistication. Controls are sophisticated now, but there is still potential for further advancement. Percentage cost change: +10.

(6) Improved Design. While the cost of high-speed sorters is expected to increase, it is probable that design improvements will reduce the cost of intermediate speed equipment. Slower sorters have already come down in price. Percentage cost change: -7.

(7) Manufacturing Techniques. As in the case of design improvements, it is believed that the cost of intermediate speed sorters will be lowered as a result of improved manufacturing methods. Percentage cost change: -5.

(8) New Materials. No change is expected.

(9) More Efficient Installation Techniques. Sorter installation methods will follow overall field work improvements. Percentage cost change: -3.

(10) Advanced Electrical/Electronic Devices and Systems. Most sorters now being sold use advanced electronics for control and for identification acquisition, i.e., scanners and voice encoders. Since the cost of this equipment has been going down, we believe there will also be a reduction in the cost of associated electronics. Percentage cost change: -2.

b. Mergers. Mergers are used to consolidate the flow from two or more conveyor lines. Current use is not widespread; consequently, development of this area has not received the attention that other devices have. They will become more important as sorters other than tilt-tray come into wider use. Net percentage cost change: +23.

c. Lifts. The principal conveyor companies make lifts to be integrated into their systems. Carton lifts are normally continuous with indexing feeds whereas pallet lifts are usually reciprocating. Present carton lifts provide a peak operating rate of 28 cartons per minute. This rate may go as high as 60 cartons per minute in the near future. Pallet lifts are also expected to show a slight speed increase. Net percentage cost change: +16.

d. Palletizers and Depalletizers. This equipment is made primarily by conveyor manufacturers and is available in rates from 30 to 120 cartons per minute. Net percentage cost change: +5.

e. Shrink and Stretch Wrap Machines. These items are made by specialty companies, who were not interviewed. However, all indications are that cost trends will not differ materially from those

of sorters; mergers, etc. Net percentage cost change: +10.

f. Strapping Machines. Automatic strapping machines are also made by specialty manufacturers and normally marketed by the strapping companies. Future cost trends for these machines are expected to follow those for the conveyor accessory category as a whole but to a lesser degree. Net percentage cost change: +5.

g. Other. Packing aids, scales and other auxiliary devices, not specifically mentioned in this section, are also available. The cost trends for these devices are expected to follow the overall pattern for computer peripherals. Net percentage cost change: +15.

9. Computers and Controllers

The advent of the minicomputer and microprocessor, and their adaptation to the control of handling equipment has produced the most significant changes to materials handling systems in recent years. This trend is expected to continue.

They have relieved central processing computers of routing control tasks and freed them for recordkeeping and direction-giving purposes. The most immediate areas of impact are considered to be: conveyor controls, storage and retrieval system controls, order-picker controls, and inventory and location records.

As mentioned previously, we have been told that any control installation involving more than $1,000 worth of relays and motor starters should be changed to programmable controllers and microprocessors to effect savings. While this gives an indication of the adaptability and economy of the electronic equipment, it is not necessarily the entire answer. Such equipment requires specialized maintenance talents not normally encountered in the typical maintenance electrician. Therefore, the installation must be large enough to justify having electronic technicians on the staff, or they must be available to the installation on short notice.

a. Greater Throughput. Throughput is not a factor that concerns this type of equipment.

b. Greater Reliability. This equipment is now more reliable than hard-wired relays, and no cost changes are expected.

c. More Restrictive Safety Requirements. Are not applicable.

d. Increased Stacking Heights. Are not applicable.

e. Control Sophistication. The use of programmable controllers and microprocessors makes it practical to provide more sophisticated controls at minimum expense and will result in additional cost even though control costs for a fixed degree of sophistication may trend downward. Percentage cost change: +6.

f. Improved Design. The nature of this equipment is in a constant state of flux and most of those interviewed indicated a downward trend in costs. Percentage cost change: -9.

g. Improved Manufacturing Techniques. Suppliers surveyed predicted a reduction in manufacturing cost as computers and controllers become more commonplace. Percentage cost change: -5.

h. New Materiels. Use of new materiels is expected to reduce costs. Percentage cost change: -5.

i. More Efficient Installation Techniques. The use of programmable controllers and microprocessors encourages the use of multiplexing control circuits to remote devices. Percentage cost change: -8.

j. Advanced Electrical/Electronic Devices and Systems. Since computers are advanced electronic devices, this factor is not applicable.

10. Intelligence Acquisition Devices

Usage of computers for recording and processing information has relieved people of much of the paperwork routine in supply activities. As one supplier stated, "Man is being eliminated from the flow of information, but not from the physical operation". To provide the necessary flow of information to the computer, several methods of input can be employed. These include keyboards, card readers, and tape readers for input of pre-assembled information. For identification and counting of materiel while in motion, and for sorting control, there are combinations of limit switches, proximity switches, photo-sensors, code readers, and voice encoders. Most of these items have been in service for an extended period of time and are reliable and standardized. No appreciable changes in cost structure are anticipated for these items. Exceptions are code readers and voice encoders which are still in the development stage and are expected to become more reliable and less expensive. Both are employed primarily to identify items moving on a conveyor and

to direct actions and/or record counts. Percentage cost changes shown below are for the entire intelligence acquisition device category. Individual changes for each type of equipment are displayed in Figure 2-2.

a. Greater Throughput. Present scanners, both fixed beam and automatic (moving beam), can read coded imprints at conveyor speeds of 5 to 500 f.p.m. Voice encoders require one to two seconds to react to each word or phrase in the memory. This implies that voice encoding will always be limited in speed, while code reading is faster than present conveyor speeds and should adequately accommodate any expected reading rate. Percentage cost change: +1.

b. Greater Reliability. Automatic scanners now read on the first valid sweep of the code as determined by the check digit at the end of the pattern. The biggest weakness in the past has been poor printing quality of the code, particularly on preproduced cardboard cartons, which lead to misreads or code rejection. Newer codes now available, plus better print control, are improving this area of weakness, and current readers are considered quite reliable. Voice encoders have an expected accuracy of 98-98½ percent. Percentage cost change: +3.

c. More Restrictive Safety Requirements. Are not applicable.

d. Increased Stacking Heights. Are not applicable.

e. Control Sophistication. Automatic scanners now use laser beams to sweep the target area because of their high light intensity. A sample of remarks obtained in our survey produced the following interesting ideas:

- There will be better lasers.
- There will be more than one color laser.
- There will be portable laser scanners.
- Laser beams will not be the scanning medium of the future.
- There will be noncontact optical character scanning.

- Component elements will be standardized, mass-produced, and users will assemble their own systems.

The conclusion to be drawn is that there is not universal agreement in the scanning field, and much development remains to be done.

Voice encoders generally have limited vocabularies, ranging from 32 to 75 words, depending on the manufacturer. They also provide for switching between vocabularies depending on the task at hand. Larger vocabularies prolong the response time. Input by telephone can be done. Up to four input stations can be handled simultaneously by a single processor. It is predicted that, in the future, equipment will be able to recognize and interpret continuous speech without prior training on a real-time basis. Voice encoding is primarily of value where the operator needs freedom to use his hands. Percentage cost change: +7.

f. Improved Design. Since this equipment is still in a development stage, design improvements are expected. Percentage cost change: -6.

g. More Efficient Manufacturing Techniques. Costs of scanning equipment have remained relatively high because the suppliers, in order to generate a market for the product, have entered into the total system design which involves many technical man-hours. Each unit or set of units is very much custom-engineered for a specific system. Today the selling price of a fixed beam scanner with interface equipment varies between $3,600 and $5,000. The cost of an automatic scanner with interface varies between $6.500 and $12,000. It is predicted that, within a few years, a standardized fixed beam scanner with required interface modules will sell for less than $1,000 and that automatic scanner packages will be less than $3,500.

Voice encoders with digital output start at $10,500 today. As they become standard packages, this price is expected to go below $6,000.

The potential exists for major cost reductions in these areas, but only after the suppliers reduce their emphasis on systems engineering and concentrate on standardizing their product. Percentage cost change: -23.

h. New Materiels. The cost of integrated circuitry has dropped dramatically, and we are told it has not bottomed out yet. Percentage cost change: -8.

i. More Efficient Installation Techniques. There is potential for reduction of field wiring. Percentage cost change: -3.

j. Advanced Electrical/Electronic Devices and Systems. This factor is not applicable since intelligence acquisition devices are themselves advanced electrical/electronic devices.

D. LABOR COST

Labor at DOD wholesale distribution activities is primarily civilian. Thus, the labor cost projections used to develop depot operating cost curves for future years are derived from projections of civilian pay obtained from within the DOD. Available civilian pay forecasts represent anticipated legislative and judicial actions based on past DOD experience.

Past and future labor cost indices are shown in Figure 2-6. Indices from 1960 to 1981 are developed from data supplied by the DOD. These indices are extended to 1986 using the average annual increase from 1976 to 1981 (approximately 7 percent).

In this Figure, indices using both 1975 and 1976 as base years are shown. By 1986 labor cost is expected to increase by 104 percent using 1975 as the base year. This increase will be used to project nominal depot labor costs to the design year since baseline labor costs used by the DODMDS Study Group are for 1975.

Using 1976 as the base year, a labor cost increase of 90 percent is forecast for the 1986 design year. This projection is developed for comparison with equipment, space, and supplies cost trends for the corresponding timeframe. This additional tabulation is required because 1976 is the base year for equipment and space costs.

The civilian pay trend from 1960 to 1986 is shown graphically in Figure 2-7. From 1960 to 1969 civilian pay rose approximately 4 percent annually. A yearly increase of about 7 percent began in 1969 and is expected to continue to 1986.

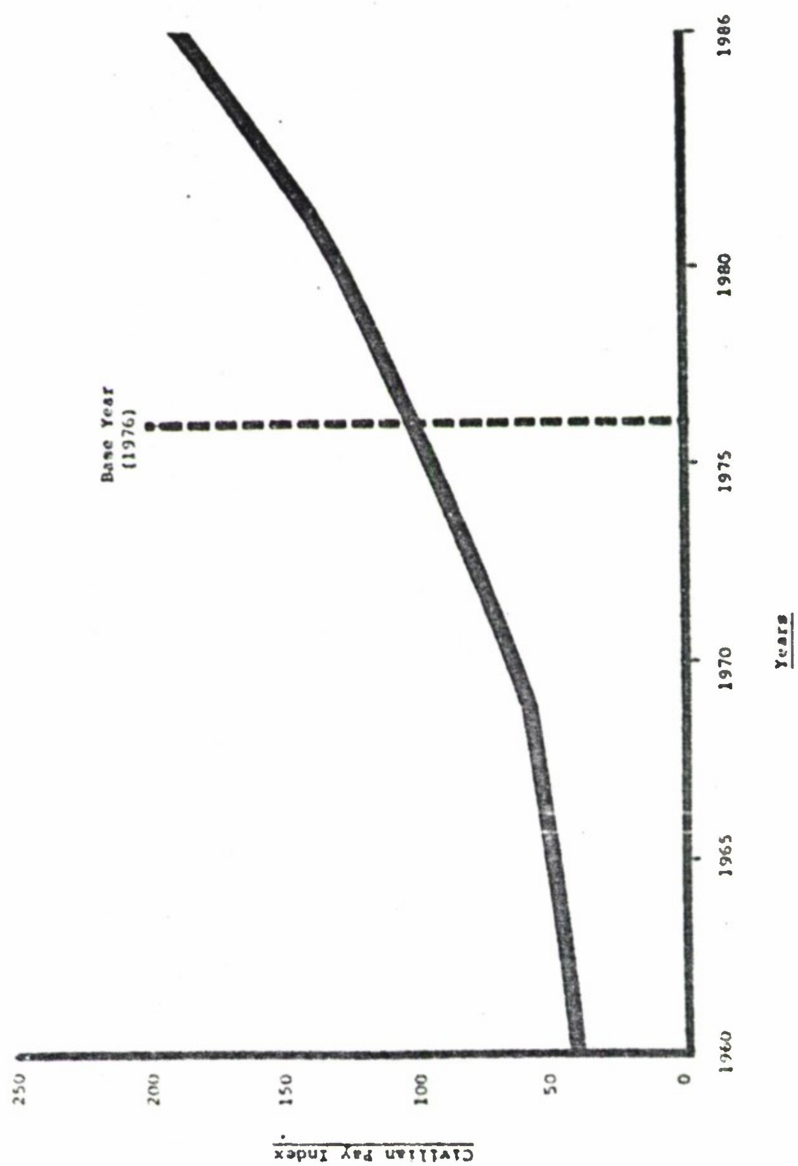


Figure 2-7

Civilian Pay Trend

(1960-1985)

E. CONSTRUCTION COST

The major cost elements comprising the segment of depot cost curves that varies directly with throughput are labor, equipment, supplies and space. Each of these cost areas must be independently projected to the 1986 design year to develop forecast curves. Projection factors used to extend labor and equipment costs are developed using methodology outlined in other sections of this Report. In this section the development of projection factors for application to current construction costs is discussed.

Construction cost projection factors are developed using a technique known as historical analogy and regression. This technique involves the correlation of known historical construction cost data with an independent index having both an historical base and a reliable forecast for the future.

Two major economic indicators (Gross National Product Index and Consumer Price Index) and seven construction cost indices were evaluated as alternatives.

The construction cost index and economic indicator paired with the most correlative historical pattern was selected to provide the forecast trend. The indices evaluated and the analysis results are shown in Exhibit C.

Using 1976 as the base year, annual values of the selected construction cost index are listed in Figure 2-8. Current space costs (1976) will be multiplied by 1.84 to determine the cost for the same space in the 1986 design year.

The graph shown in Figure 2-9 shows the trend of construction costs from 1960 to 1986 using 1976 as the base year.

To reinforce our space cost projection development methodology and calculations, we compared our derived annual values with the existing DOD Forecast. The results of this comparison are shown in Figure 2-10. Although the Military Construction Cost Index is not available for 1986, the comparison of values for 1985 shows only a 3 percent difference. The percent difference in any one year from 1960 to 1985 is never greater than eight percent.

During the development of nominal depot cost curves, rack-supported buildings may be considered as an alternative to

Year	Annual index values (base year 1976)
1960	39
1961	39
1962	40
1963	41
1964	42
1965	44
1966	46
1967	49
1968	52
1969	56
1970	60
1971	65
1972	71
1973	75
1974	83
1975	92
1976	100
1977	113
1978	122
1979	130
1980	138
1981	145
1982	152
1983	159
1984	167
1985	175
1986	184

Source: Exhibit C.

Figure 2-8

Construction Cost Index

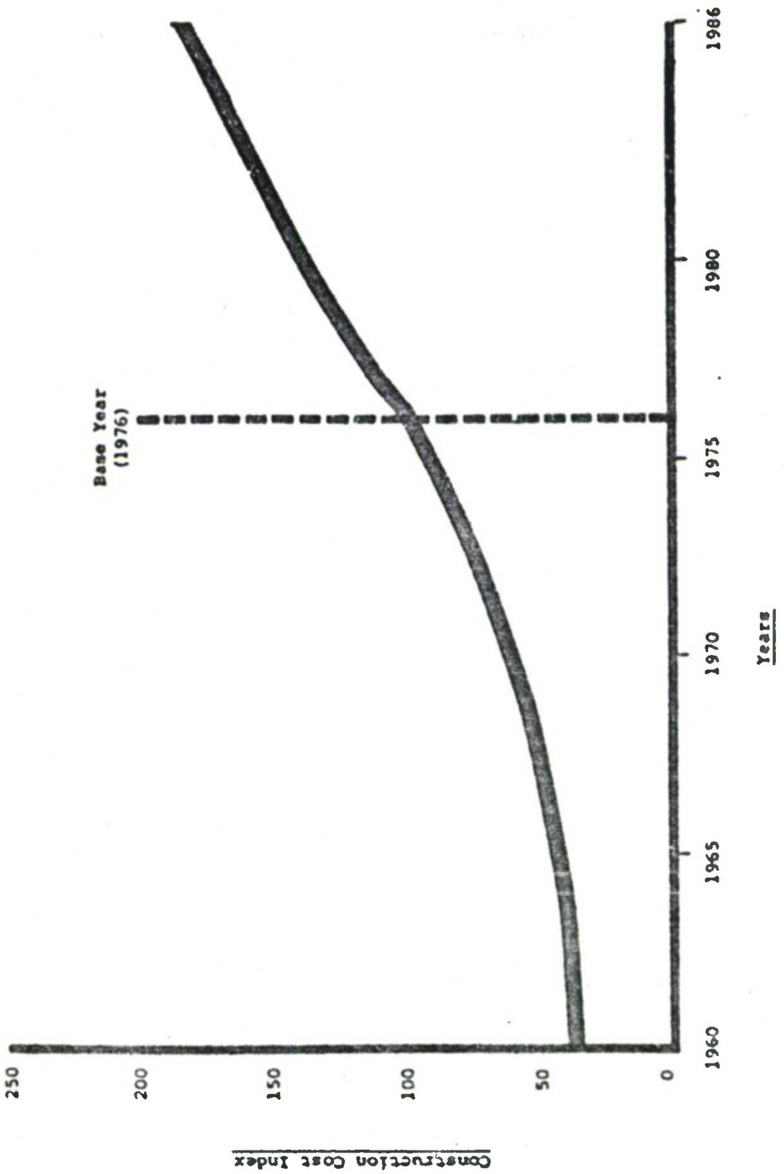


Figure 2-9

Construction Cost Trend

(1960-1986)

Year	DS/SD selected index values[a]	MCC index values[b]	Difference (MCC-DS/SD)	Percent difference[c]
1960	92	95	3	3
1961	93	95	2	2
1962	95	97	2	2
1963	97	99	2	2
1964	100	100	-	-
1965	103	102	-1	-1
1966	108	106	-2	-2
1967	115	111	-4	-4
1968	123	115	-8	-7
1969	132	122	-10	-8
1970	141	134	-7	-5
1971	154	144	-10	-7
1972	166	153	-13	-8
1973	177	173	-4	-2
1974	196	194	-2	-1
1975	217	217	-	-
1976	236	239	3	1
1977	266	266	-	-
1978	288	286	-2	-1
1979	307	305	-2	-1
1980	324	323	-1	-
1981	341	341	-	-
1982	358	361	3	1
1983	375	381	6	2
1984	394	403	9	2
1985	413	426	13	3
1986	433	d	-	-

[a]Source: Exhibit C.

[b]Military construction cost. Source: Department of Defense Deflators (Outlays), Office of the Assistant Secretary of Defense (Comptroller), 28 January 1976.

[c]Percent difference = MCC-DS/SD/MCC x 100.

[d]MCC not available for 1986.

Figure 2-10

Construction Cost Forecast Comparison --
DS/SD Selected Index and Military Construction Cost Index

(Base year 1964)

conventional structures. While rack-supported construction is less expensive than conventional, the projected cost trends are the same for both types. The construction cost forecast factors shown in Figure 2-8 will be used to project the cost of either construction alternative to 1986.

F. SUPPLIES COST

In addition to the costs of labor, equipment and space, the cost of supplies is a component of direct variable depot cost. Projection factors for application to the supplies cost component are taken from Operating and Maintenance (O&M) cost projections developed within the DOD.

Figure 2-11 is a listing of the O&M factors for each year from 1960 to 1986. Indices using both 1975 and 1976 as the base year are included.

A 71 percent increase in supplies cost is forecasted for 1986 using 1975 as the base year. The increase from 1976 to 1986 is expected to be 58 percent.

Year	Annual index values (base year 1975)	Annual index values (base year 1976)
1960	51	47
1961	52	48
1962	51	47
1963	52	48
1964	52	48
1965	53	49
1966	54	50
1967	55	51
1968	57	52
1969	58	54
1970	61	57
1971	65	60
1972	67	62
1973	69	64
1974	81	75
1975	100	92
1976	108	100
1977	116	108
1978	124	114
1979	130	120
1980	136	125
1981	141	130
1982	146	135
1983	152	141
1984	158	146
1985	164	152
1986	171	158

Source: Department of Defense Deflators (Outlays), Office of the Assistant Secretary of Defense (Comptroller), 28 January 1976.

Figure 2-11

Operating and Maintenance Cost Indices

CHAPTER 3
COST DEVELOPMENT

Nominal depot costs, reflecting the current state-of-the-art in handling and storage techniques and concepts, were developed around the materials handling flow path concept. A materials handling flow path is defined as a group of NSN's having similar handling and storage requirements. For cost development purposes DODMDS items were structured into eleven flow paths:

Flow path number	Description
1	Items requiring cold storage
2	Hazardous items
3	Items requiring security storage
4	Small arms
5	Ships, boats, aircraft, railway equipment
6	Aircraft engines
7	Vehicles
8	Tires
9	Subsistence
10	All other items -- large (nonpalletizable items)
11	All other items -- small (bin and palletizable items)

Nominal costs were constructed in terms of their four principal cost elements -- space, labor, equipment, and supplies -- for each flow path. Each of these cost elements was developed on, or converted to, an annual basis for subsequent analysis.

Projected direct variable depot costs for 1986 were developed by applying the appropriate forecast factor to each nominal depot cost element, at the minimum and maximum throughput level, for each flow path. This development is shown by flow path in Exhibit D.

By determining the linear relationship between the two throughput end points, forecast cost values over the entire throughput range were developed. These linear curves are shown in Exhibit E.

Total annual costs for 1986 for each flow path are listed on Figure 3-1. Total annual costs and unit costs per hundredweight of throughput are shown for both minimum and maximum throughput levels in this Figure.

Flow path	Total system throughput level: Throughput (1,000 cwt.)	Total annual cost[a] ($1,000)	Unit cost ($/cwt.)	40 depot throughput level: Throughput (1,000 cwt.)	Total annual cost[a] ($1,000)	Unit cost ($/cwt.)
1	6	988	164.67	0.15	49	326.67
2	918	1,346	1.47	23	81	3.52
3	122	1,094	8.97	3.1	136	43.87
4	162	2,909	17.96	4.1	93	22.68
5	1,053	3,335	3.17	26	258	9.92
6	948	6,088	6.42	24	347	14.46
7	6,208	23,855	3.84	155	1,528	9.86
8	502	3,154	6.28	12.6	140	11.11
9	11,237	13,039	1.16	281	468	1.67
10	6,703	147,076	21.94	168	9,302	55.37
11	13,687	177,185	12.95	342	5,235	15.31
Total	41,546	380,069	9.15	1,038.95	17,637	16.98

[a]Depot grouping (Region) II values.

Figure 3-1

Forecast Cost/Throughput Relationships

Because of the storage orientation of the DOD system, space represents the largest cost element — 42 percent of total system annual cost at the maximum throughput level. Annual costs for all cost elements are shown in Figure 3-2 at the total system throughput level. Figure 3-3 is a listing of the annual costs by element at the minimum throughput level.

Flow path	Annual cost ($1,000)				
	Space	Equipment	Labor	Supplies	Total
1	442	133	387	16	988
2	132	116	1,081	17	1,346
3	515	168	378	33	1,074
4	655	366	1,845	43	2,909
5	-	1,207	1,455	673	3,335
6	4,142	656	887	403	6,088
7	16,085	2,593	3,629	1,548	23,855
8	335	250	2,523	46	3,154
9	1,387	1,032	10,434	186	13,039
10	84,329	31,756	28,420	2,571	147,076
11	52,241	34,860	86,051	4,033	177,185
Total	160,263	73,137	137,100	9,569	380,069
Percent of total	42	19	36	3	100

[a]Depot Grouping (Region) II cost values.

Figure 3-2

Annual Forecast Cost[a] Elements — Total System Throughput Level

	Annual cost ($1,000)				
Flow path	Space	Equipment	Labor	Supplies	Total
1	18	14	15	2	49
2	9	19	51	2	81
3	50	39	44	3	136
4	18	24	49	2	93
5	-	66	173	19	258
6	190	34	114	9	347
7	819	175	494	40	1,528
8	17	29	91	3	140
9	58	98	303	9	468
10	5,273	3,079	880	70	9,302
11	1,307	1,972	1,850	106	5,235
Total	7,757	5,549	4,064	265	17,637
Percent of total	44	31	23	2	100

[a]Depot Grouping (Region) II cost values.
[b]Forty depot throughput level.

Figure 3-3

Annual Forecast Cost[a] Elements — Minimum[b] Throughput Level

Flow path	Space	Equipment	Labor	Supplies	Total
	Annual cost ($1,000)				
1	18	14	15	2	49
2	9	19	51	2	81
3	50	39	44	3	136
4	18	24	49	2	93
5	-	66	173	19	258
6	190	34	114	9	347
7	819	175	494	40	1,528
8	17	29	91	3	140
9	58	98	303	9	468
10	5,273	3,079	880	70	9,302
11	1,307	1,972	1,850	106	5,235
Total	7,757	5,549	4,064	265	17,637
Percent of total	44	31	23	2	100

[a]Depot Grouping (Region) II cost values.
[b]Forty depot throughput level.

Figure 3-3

Annual Forecast Cost[a] Elements -- Minimum[b] Throughput Level

EXHIBIT A

PLANNING ASSUMPTIONS

1. The design year for the forecasting effort is 1986.

2. Operating and maintenance cost projections from the DOD Deflators (Outlays) dated 28 January 1976 can be used to forecast supplies costs.

3. Civilian pay projections are representative of projections for labor costs at depots.

<u>EXHIBIT B</u>

<u>LIST OF FIELD INTERVIEWS</u>

Date (1976)	Firm visited	Location	Contact and title
18 June	S.I. Handling Systems	Easton, PA	Tony Rotondo, Manager Sales Engineering
7 July	The Raymond Corp.	Greene, NY	Christian Gibson, Vice President, Engineering Jay Fergeson, General Manager, Mobility Systems
8 July	Computer Identics Corp.	Westwood, MA	John M. Hill, Vice President, Industrial Systems
9 July	The Logan Co. Division ATO Inc.	Louisville, KY	Joseph M. Hammond President A. W. Fesold, Vice President, Marketing C. G. East, Vice President, Sortation System Victor Leonard, Director, Conveyor Engineering
12 July	Barrett Electronics Corp.	Northbrook, IL	John Peterson Chief Engineer
13 July	ACCO	Melrose Park, IL	Garry Pontell Regional Manager Svend Rondum Proposal Manager Integrated Handling Systems
19 July	Litton Unit Handling Systems	Florence, KY	Lloyd Robertson, Vice President, Marketing Donald Ruward, Manager, Storage Systems
20 July	Rapistan, Inc.	Grand Rapids, MI	Aman Oumedian, Manager, Systems Marketing Howard Zollinger, Manager, Control Operations Peter Tegner, Manager, Design and Development

Date (1976)	Firm visited	Location	Contact and title
22 July	Interlake, Inc.	Chicago, IL	Thomas C. Aylmer, Manager, National Accounts Storage Products Thomas J. Siska, Manager, Engineering Storage and Handling Systems Joseph R. Urbank, Manager, Product Development and Business Planning, Storage Products
26 July	U.S. Postal Service R&D Branch	Rockville, MA	Hassell Crouch, Manager of Systems Development
17 August	Moeler/Airmatic & Electronic Systems	New York, NY	Lester Garb Area Manager
17 August	Threshold Technology, Inc.	Delran, NJ	J. C. Collins, Vice President, Marketing Irwin Goldberg, OEM Marketing Manager
26 August	Industrial Truck Operations, Otis Elevator Co.	Cleveland, OH	Robert Heiser, Manager, Marketing Development
31 August	Jervis B. Webb Co.	Detroit, MI	B. B. Billiu, Manager, Military Sales
1 September	Material Handling Division Rexnord, Inc.	Danville, KY	David Shenton, Vice President, Marketing John Kurowski Industry Manager
8 September	Electronics Corporation of America Photo Switch Division	Cambridge, MA	Stanley Davis Director of Sales Donald Hartmann, System Engineering Manager
20 September	Alvey/Control Flow, Inc.	West Willow, PA	E. T. Holland, Executive Vice President
23 September	MRC Corp., Division Scope Inc.	Hunt Valley, MO	Vito Brigida, Corporate Marketing Manager John Mackey, Manager, Scanner Systems
23 September	Scope Electronics Div.	Reston, VA	Vito Brigida, Corporate Marketing Manager Wally Birdseye Engineer

Date (1976)	Firm visited	Location	Contact and title
19 October	Avon Products Corp.	Rye, NY	George Davis Plant Manager A. C. Curry, Materials Handling Engineer
28 October	ACCO Symposium	Newark, NJ	George Boutom Director Dr. John A. White Professor, Georgia Institute of Technology John Slovak, A.I.A. Architect Jack Parks, Supervisor, Computer Software Development, Integrated Handling Systems Gerald Hill, Superintendent, Parts Distribution Detroit-Allison Division, GMC

In addition to the above field interviews, the following educators and editors in the materials handling field were surveyed by mail:

Mr. Miles J. Rowan
Editor and Assistant Publisher
Modern Materials Handling Magazine

Mr. Bernard Knill
Executive Editor
Material Handling Engineering Magazine

Dr. James Apple
Georgia Institute of Technology

Dr. John A. White, Jr.
Associate Professor
School of Industrial and Systems Engineering
Georgia Institute of Technology

Dr. Roddel Reed, Jr.
Purdue University

Dr. David Freeman
Northeastern University

Dr. Thomas Cullinane
Notre Dame University

EXHIBIT C

CONSTRUCTION COST FORECAST DEVELOPMENT

The methodology and data sources used to develop factors to project current space costs to the 1986 design year are discussed in Exhibit C. This Exhibit includes four Schedules:

Schedule C-I, Major Cost Indices Evaluated. Annual historical values of the two economic indicators, the Gross National Product Index and the Consumer Price Index, and the seven construction cost indices used in our evaluation are shown in Schedule C-I. Values for the Military Construction Cost Index provided by the DOD are also listed as a basis for comparison.

Each of these seven construction cost indices was tested against each of the two economic indicators using regression analysis to identify similar patterns of growth from 1960 to 1976.

In Schedule C-II, Comparison of Alternative Indices, the results of our evaluation are shown. In each case, an index of determination value approaching unity is achieved indicating that the two variables being tested are both a function of a third variable that need not be identified. Using the "best" correlation of those evaluated, we selected the GNP Index as the known economic index and the Boeckh Index as the construction cost index to be projected to 1986.

Based on historical relationship between the GNP Index and the Boeckh Index, the latter was projected from 1977 to 1985 again using the regression technique. Resulting annual values from 1960 to 1986, with a base year of 1964, for both indices are listed in Schedule C-III, Gross National Product and Boeckh Indices. Values for 1986 were approximated since GNP Index stops at 1985.

Schedule C-IV, GNP and Boeckh Index Trend shows the relationship of the two indices in graphic form. Of particular interest are the coincidental slope changes for these two variables in 1973, 1976 and 1978.

Schedule C-1

Major Cost Indices Evaluated

(Base year -- 1964)

	Economic indications		Construction cost indices							
Year	Gross National Product Index[a]	Consumer Price Index[a]	Department of Commerce Composite Index[b]	American Appraisal Company Index[b]	"Boeckh Index" Commercial and Factory Buildings[b]	Engineering News-Record Construction Index[b]	Turner Construction Company Index[b]	Dodge Cost Index -- New York base[c]	Dodge Cost Index -- Washington, D.C. base[c]	Military Construction Cost Index[a]
1960	94.9	95.2	92.0	90.6	92.3	88.0	93.6	91.6	92.3	95.2
1961	96.4	96.4	92.9	92.3	93.1	90.6	94.5	93.5	94.2	95.1
1962	97.4	97.4	95.5	94.9	95.1	93.0	95.4	96.8	94.9	96.5
1963	98.6	98.6	97.3	97.4	97.2	96.3	98.2	97.4	96.3	98.6
1964	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1965	101.8	101.3	102.7	103.4	103.4	103.8	103.7	102.2	102.5	102.0
1966	103.9	103.5	106.3	108.5	107.8	108.9	106.4	102.7	102.7	106.0
1967	107.2	106.7	111.6	113.7	114.8	114.4	110.1	106.7	105.9	110.5
1968	111.0	110.2	117.0	121.4	122.7	123.4	117.4	108.9	106.4	114.9
1969	115.8	115.6	126.8	131.6	131.5	135.8	128.4	112.2	114.1	122.4
1970	122.2	122.4	135.7	141.9	141.4	147.5	142.2	121.0	120.7	133.8
1971	128.4	128.7	143.0	156.9	153.7	167.9	149.0	130.6	132.6	144.4
1972	133.1	133.4	150.7	171.7	166.2	186.3	157.4	140.3	146.0	153.4
1973	138.3	138.7	164.9	189.9	177.2	202.0	169.6	156.5	159.3	172.9
1974	149.5	151.1	192.8	201.2	196.3	215.3	207.0	171.7	175.6	193.8
1975	165.7	167.8	211.4	214.9	216.7	235.6	219.1	180.9	185.4	217.2
1976	176.0	180.0	219.3	230.8	235.7	254.9	221.3	186.2	187.9	238.5

[a] Department of Defense Deflators (Outlays), Office of the Assistant Secretary of Defense (Comptroller), 28 January 1976.

[b] "Construction Review," U.S. Department of Commerce; May 1976, p. 52; May 1971, p. 46; December 1965, p.42.

[c] "United States and Canadian Construction Cost Indices," Dodge Building Services, McGraw-Hill Information Systems Company, April 1976.

Schedule C-II

Comparison of Alternative Indices

(1960-1976)

Construction cost indices	Correlative economic indices			
	Gross National Product		Consumer Price Index	
	Best fit curve type[a]	Index of deter-mination[b]	Best fit curve type[a]	Index of deter-mination[b]
American Appraisal Company	1	0.977	1	0.970
"Boeckh Index"[c]	1	0.995[c]	1	0.993[c]
Engineering News-Record	1	0.980	1	0.976
Turner Construction Company	2	0.984	2	0.982
Department of Commerce	1	0.991	1	0.990
Dodge — New York	2	0.983	2	0.983
Dodge — Washington, D.C.	2	0.980	2	0.979

[a]Curve types: 1 — linear; $Y = A + BX$.
2 — hyperbolic; $Y = X/A + BX$.

[b]Index of determination = Correlation coefficient squared.

[c]"Boeckh Index" selected by DS/SD for space cost forecasting.

Schedule C-III

Gross National Product and Boeckh Indices

(1960-1986, base year 1964)

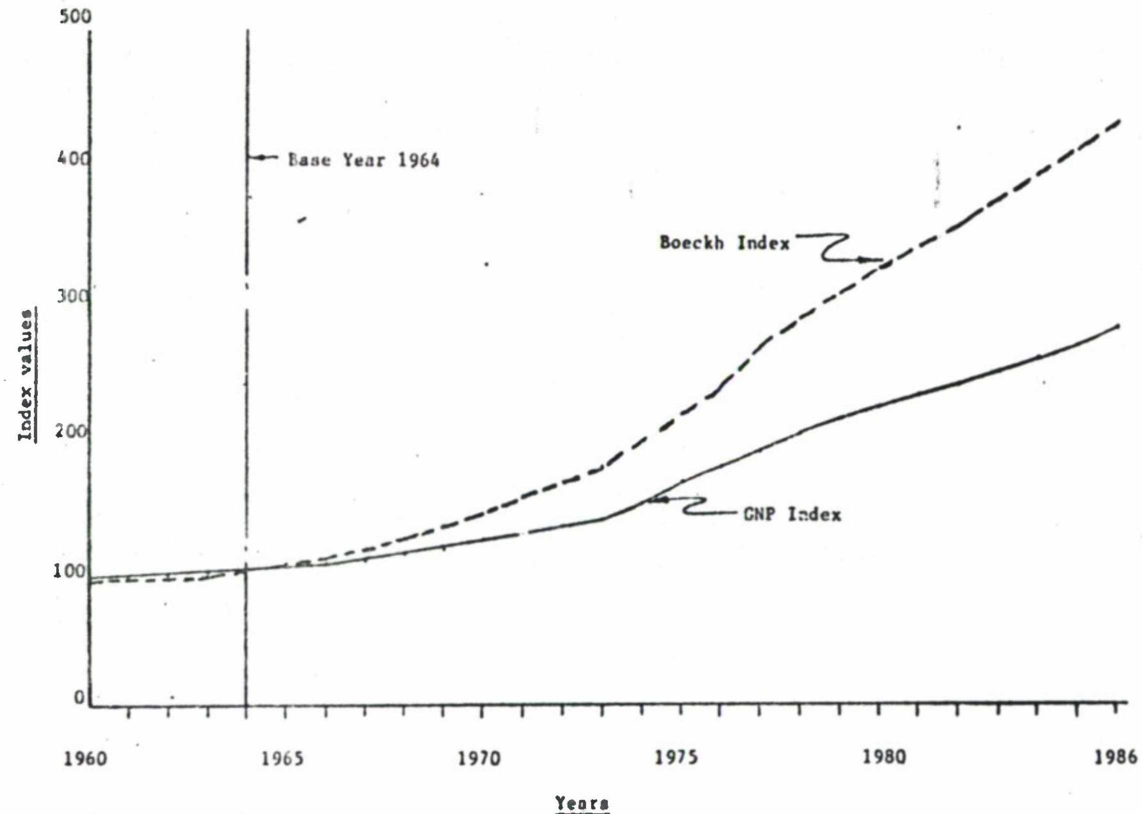
Year	GNP[a]	Boeckh Index[b]
1960	94.9	92.3
1961	96.4	93.1
1962	97.4	95.1
1963	98.6	97.2
1964	100.0	100.0
1965	101.8	103.4
1966	103.9	107.8
1967	107.2	114.8
1968	111.0	122.7
1969	115.8	131.5
1970	122.2	141.4
1971	128.4	153.7
1972	133.1	166.2
1973	138.3	177.2
1974	149.5	196.3
1975	165.7	216.7
1976	176.0	235.7
1977	189.3	265.7
1978	201.1	287.6
1979	211.8	307.4
1980	221.0	324.4
1981	229.8	340.7
1982	239.0	357.7
1983	248.6	375.4
1984	258.6	393.7
1985	268.9	413.0
1986	279.6	433.0

[a]1960-1985 values from Department of Defense Deflators (Outlays), Office of the Assistant Secretary of Defense (Comptroller), 28 January 1976. Linearly extended to 1986.

[b]1960-1976 from Schedule C-I, projected to 1986 using historical analogy and least squares regression technique based on comparison to GNP.

Schedule C-IV

GNP and Boeckh Index Trend



Source: Schedule C-III.

EXHIBIT D

FORECAST COST SUMMARIES

Annual direct variable costs projected to 1986 for each of the eleven flow paths are shown in this Exhibit. Forecast costs at the maximum (total system) and minimum (40 depot) throughput levels are shown.

For each flow path, current state-of-the-art annual costa for apace, labor, equipment and supplies are listed for the two extreme throughput levels. Forecast factors for individual coat components are applied aod resulting forecast annual costs calculated.

State-of-the-art and forecaat annual costs are shown for each depot grouping or region.

FORECAST COST SUMMARY
(Thousands of dollars)

Flow path 1

Throughput volume (No. of depots) 1

State-of-the-Art Annual Cost			
Description	Region I	Region II	Region III
Space	239	240	247
Equipment	78	78	78
Labor	208	209	215
Supplies	10	10	10
Total Annual cost - State-of-the-art (1976)	535	537	550

Forecast Annual Cost			
Description	Region I	Region II	Region III
Space (S.O.A. cost x 1.84)	440	442	454
Equipment (S.O.A. cost x 1.70)	133	133	133
Labor (S.O.A. cost x 1.90)	395	397	409
Supplies (S.O.A. cost x 1.58)	16	16	16
Total annual cost - Forecast (1986)	984	988	1,012

FORECAST COST SUMMARY
(Thousands of dollars)

Flow path 1

Throughput volume (No. of depots) 40

State-of-the-Art Annual Cost			
Description	Region I	Region II	Region III
Space	10	10	11
Equipment	8	8	8
Labor	8	8	8
Supplies	1	1	1
Total Annual cost - State-of-the-art (1976)	27	27	28

Forecast Annual Cost			
Description	Region I	Region II	Region III
Space (S.O.A. cost x 1.84)	18	18	20
Equipment (S.O.A. cost x 1.70)	14	14	14
Labor ...O.A. cost x 1.90)	15	15	15
Supplies (S.O.A. cost x 1.58)	2	2	2
Total annual cost - Forecast (1986)	49	49	51

FORECAST COST SUMMARY
(Thousands of dollars)

Flow path 2

Throughput volume (No. of depots) 1

State-of-the-Art Annual Cost			
Description	Region I	Region II	Region III
Space	63	72	78
Equipment	68	68	68
Labor	528	569	627
Supplies	10	11	12
Total Annual cost - State-of-the-art (1976)	669	720	785

Forecast Annual Cost			
Description	Region I	Region II	Region III
Space (S.O.A. cost x 1.84)	116	132	144
Equipment (S.O.A. cost x 1.70)	116	116	116
Labor (S.O.A. cost x 1.90)	1,003	1,081	1,191
Supplies (S.O.A. cost x 1.58)	16	17	19
Total annual cost - Forecast (1986)	1,251	1,346	1,470

FORECAST COST SUMMARY
(Thousands of dollars)

Flow path 2

Throughput volume (No. of depots) 40

State-of-the-Art Annual Cost			
Description	Region I	Region II	Region III
Space	4	5	5
Equipment	11	11	11
Labor	25	27	30
Supplies	1	1	1
Total Annual cost - State-of-the-art (1976)	41	44	47

Forecast Annual Cost			
Description	Region I	Region II	Region III
Space (S.O.A. cost x 1.84)	7	9	9
Equipment (S.O.A. cost x 1.70)	19	19	19
Labor (S.O.A. cost x 1.90)	48	51	57
Supplies (S.O.A. cost x 1.58)	2	2	2
Total annual cost - Forecast (1986)	76	81	87

FORECAST COST SUMMARY
(Thousands of dollars)

Flow path 3

Throughput volume (No. of depots) 1

State-of-the-Art Annual Cost			
Description	Region I	Region II	Region III
Space	249	280	308
Equipment	99	99	99
Labor	193	199	219
Supplies	19	21	23
Total Annual cost - State-of-the-art (1976)	560	599	649

Forecast Annual Cost			
Description	Region I	Region II	Region III
Space (S.O.A. cost x 1.84)	458	575	567
Equipment (S.O.A. cost x 1.70)	168	168	168
Labor (S.O.A. cost x 1.90)	367	378	416
Supplies (S.O.A. cost x 1.58)	30	33	36
Total annual cost - Forecast (1986)	1,023	1,094	1,187

FORECAST COST SUMMARY
(Thousands of dollars)

Flow path 3

Throughput volume (No. of depots) 40

State-of-the-Art Annual Cost			
Description	Region I	Region II	Region III
Space	25	27	30
Equipment	23	23	23
Labor	22	23	25
Supplies	1	2	2
Total Annual cost - State-of-the-art (1976)	72	75	80

Forecast Annual Cost			
Description	Region I	Region II	Region III
Space (S.O.A. cost x 1.84)	48	50	55
Equipment (S.O.A. cost x 1.70)	39	39	39
Labor (S.O.A. cost x 1.90)	42	44	48
Supplies (S.O.A. cost x 1.58)	2	3	3
Total annual cost - Forecast (1986)	131	136	145

FORECAST COST SUMMARY
(Thousands of dollars)

Flow path - 4

Throughput volume (No. of depots) 1

State-of-the-Art Annual Cost			
Description	Region I	Region II	Region III
Space	312	356	389
Equipment	215	215	215
Labor	919	971	1,074
Supplies	23	27	31
Total Annual cost - State-of-the-art (1976)	1,469	1,569	1,709

Forecast Annual Cost			
Description	Region I	Region II	Region III
Space (S.O.A. cost x 1.84)	574	655	716
Equipment (S.O.A. cost x 1.70)	366	366	366
Labor (S.O.A. cost x 1.90)	1,746	1,845	2,041
Supplies (S.O.A. cost x 1.58)	36	43	49
Total annual cost - Forecast (1986)	2,722	2,909	3,172

FORECAST COST SUMMARY
(Thousands of dollars)

Flow path 4

Throughput volume (No. of depots) 40

State-of-the-Art Annual Cost			
Description	Region I	Region II	Region III
Space	9	10	10
Equipment	14	14	14
Labor	24	26	27
Supplies	1	1	1
Total Annual cost - State-of-the-art (1976)	48	51	52

Forecast Annual Cost			
Description	Region I	Region II	Region III
Space (S.O.A. cost x 1.84)	17	18	18
Equipment (S.O.A. cost x 1.70)	24	24	24
Labor (S.O.A. cost x 1.90)	46	49	51
Supplies (S.O.A. cost x 1.58)	2	2	2
Total annual cost - Forecast (1986)	89	93	95

FORECAST COST SUMMARY
(Thousands of dollars)

Flow path 5

Throughput volume (No. of depots) 1

State-of-the-Art Annual Cost			
Description	Region I	Region II	Region III
Space			
Equipment	710	710	710
Labor	711	766	859
Supplies	420	426	437
Total Annual cost - State-of-the-art (1976)	1,841	1,902	2,006

Forecast Annual Cost			
Description	Region I	Region II	Region III
Space (S.O.A. cost x 1.84)			
Equipment (S.O.A. cost x 1.70)	1,207	1,207	1,207
Labor (S.O.A. cost x 1.90)	1,351	1,455	1,632
Supplies (S.O.A. cost x 1.58)	664	673	690
Total annual cost - Forecast (1986)	3,222	3,335	3,529

FORECAST COST SUMMARY
(Thousands of dollars)

Flow path 5

Throughput volume (No. of depots) 40

State-of-the-Art Annual Cost			
Description	Region I	Region II	Region III
Space			
Equipment	39	39	39
Labor	87	91	102
Supplies	11	12	12
Total Annual cost - State-of-the-art (1976)	137	142	153

Forecast Annual Cost			
Description	Region I	Region II	Region III
Space (S.O.A. cost x 1.84)			
Equipment (S.O.A. cost x 1.70)	66	66	66
Labor (S.O.A. cost x 1.90)	165	173	194
Supplies (S.O.A. cost x 1.58)	17	19	19
Total annual cost - Forecast (1986)	248	258	279

FORECAST COST SUMMARY
(Thousands of dollars)

Flow path 6

Throughput volume (No. of depots) 1

State-of-the-Art Annual Cost			
Description	Region I	Region II	Region III
Space	2,066	2,251	2,420
Equipment	386	386	386
Labor	450	467	528
Supplies	255	255	255
Total Annual cost - State-of-the-art (1976)	3,157	3,359	3,589

Forecast Annual Cost			
Description	Region I	Region II	Region III
Space (S.O.A. cost x 1.84)	3,801	4,142	4,453
Equipment (S.O.A. cost x 1.70)	656	656	656
Labor (S.O.A. cost x 1.90)	855	887	1,003
Supplies (S.O.A. cost x 1.58)	403	403	403
Total annual cost-Forecast (1986)	5,715	6,088	6,515

FORECAST COST SUMMARY
(Thousands of dollars)

Flow path 6

Throughput volume (No. of depots) 40

State-of-the-Art Annual Cost			
Description	**Region I**	**Region II**	**Region III**
Space	92	103	113
Equipment	20	20	20
Labor	59	60	67
Supplies	6	6	6
Total Annual cost - State-of-the-art (1976)	177	189	206

Forecast Annual Cost			
Description	Region I	Region II	Region III
Space (S.O.A. cost x 1.84)	169	190	208
Equipment (S.O.A. cost x 1.70)	34	34	34
Labor (S.O.A. cost x 1.90)	112	114	127
Supplies (S.O.A. cost x 1.58)	9	9	9
Total annual cost - Forecast (1986)	324	347	378

FORECAST COST SUMMARY
(Thousands of dollars)

Flow path 7

Throughput volume (No. of depots) 1

State-of-the-Art Annual Cost			
Description	Region I	Region II	Region III
Space	7,658	8,742	9,576
Equipment	1,524	1,525	1,524
Labor	1,788	1,910	2,115
Supplies	980	980	981
Total Annual cost - State-of-the-art (1976)	11,950	13,157	14,196

Forecast Annual Cost			
Description	Region I	Region II	Region III
Space (S.O.A. cost x 1.84)	14,091	16,085	176,620
Equipment (S.O.A. cost x 1.70)	2,591	2,593	2,591
Labor (S.O.A. cost x 1.90)	3,397	3,629	4,019
Supplies (S.O.A. cost x 1.58)	1,548	1,548	1,550
Total annual cost-Forecast (1986)	21,627	23,855	25,780

FORECAST COST SUMMARY
(Thousands of dollars)

Flow path 7

Throughput volume (No. of depots) 40

State-of-the-Art Annual Cost			
Description	Region I	Region II	Region III
Space	390	445	487
Equipment	103	103	101
Labor	244	260	286
Supplies	25	25	25
Total Annual cost - State-of-the-art (1976)	762	833	899

Forecast Annual Cost			
Description	Region I	Region II	Region III
Space (S.O.A. cost x 1.84)	718	819	896
Equipment (S.O.A. cost x 1.70)	175	175	172
Labor (S.O.A. cost x 1.90)	464	494	543
Supplies (S.O.A. cost x 1.58)	40	40	40
Total annual cost - Forecast (1986)	1,397	1,528	1,651

FORECAST COST SUMMARY
(Thousands of dollars)

Flow path 8

Throughput volume (No. of depots) 1

State-of-the-Art Annual Cost			
Description	Region I	Region II	Region III
Space	158	182	198
Equipment	147	147	147
Labor	1,230	1,328	1,467
Supplies	25	29	29
Total Annual cost - State-of-the-art (1976)	1,560	1,686	1,841

Forecast Annual Cost			
Description	Region I	Region II	Region III
Space (S.O.A. cost x 1.84)	291	335	364
Equipment (S.O.A. cost x 1.70)	250	250	250
Labor (S.O.A. cost x 1.90)	2,337	2,523	2,787
Supplies (S.O.A. cost x 1.58)	40	46	46
Total annual cost - Forecast (1986)	2,918	3,154	3,447

FORECAST COST SUMMARY
(Thousands of dollars)

Flow path 8

Throughput volume (No. of depots) 40

State-of-the-Art Annual Cost			
Description	Region I	Region II	Region III
Space	8	9	10
Equipment	17	17	17
Labor	43	48	56
Supplies	2	2	2
Total Annual cost - State-of-the-art (1976)	70	76	85

Forecast Annual Cost			
Description	Region I	Region II	Region III
Space (S.O.A. cost x 1.84)	15	17	18
Equipment (S.O.A. cost x 1.70)	29	29	29
Labor (S.O.A. cost x 1.90)	82	91	106
Supplies (S.O.A. cost x 1.58)	3	3	3
Total annual cost-Forecast (1986)	129	140	156

FORECAST COST SUMMARY
(Thousands of dollars)

Flow path 9

Throughput volume (No. of depots) 1

State-of-the-Art Annual Cost			
Description	Region I	Region II	Region III
Space	660	754	823
Equipment	607	607	608
Labor	5,133	5,492	6,093
Supplies	111	118	123
Total Annual cost - State-of-the-art (1976)	6,511	6,971	7,647

Forecast Annual Cost			
Description	Region I	Region II	Region III
Space (S.O.A. cost x 1.84)	1,215	1,387	1,514
Equipment (S.O.A. cost x 1.70)	1,032	1,032	1,033
Labor (S.O.A. cost x 1.90)	9,752	10,434	11,576
Supplies (S.O.A. cost x 1.58)	175	186	194
Total annual cost - Forecast (1986)	12,174	13,039	14,317

FORECAST COST SUMMARY
(Thousands of dollars)

Flow path 9

Throughput volume (No. of depots) 40

State-of-the-Art Annual Cost			
Description	Region I	Region II	Region III
Space	28	31	34
Equipment	58	58	58
Labor	149	160	177
Supplies	5	6	7
Total Annual cost - State-of-the-art (1976)	240	255	276

Forecast Annual Cost			
Description	Region I	Region II	Region III
Space (S.O.A. cost x 1.84)	51	58	63
Equipment (S.O.A. cost x 1.70)	98	98	98
Labor (S.O.A. cost x 1.90)	283	303	336
Supplies (S.O.A. cost x 1.58)	9	9	10
Total annual cost - Forecast (1986)	441	468	507

FORECAST COST SUMMARY
(Thousands of dollars)

Flow path 10

Throughput volume (No. of depots) 1

State-of-the-Art Annual Cost			
Description	Region I	Region II	Region III
Space	40,212	45,831	50,270
Equipment	18,680	18,680	18,680
Labor	13,980	14,958	16,595
Supplies	1,520	1,627	1,805
Total Annual cost - State-of-the-art (1976)	74,392	81,096	87,350

Forecast Annual Cost			
Description	Region I	Region II	Region III
Space (S.O.A. cost x 1.84)	73,990	84,329	92,497
Equipment (S.O.A. cost x 1.70)	31,756	31,756	31,756
Labor (S.O.A. cost x 1.90)	26,562	28,420	31,531
Supplies (S.O.A. cost x 1.58)	2,402	2,571	2,852
Total annual cost - Forecast (1986)	134,710	147,076	158,636

FORECAST COST SUMMARY
(Thousands of dollars)

Flow path 10

Throughput volume (No. of depots) 40

State-of-the-Art Annual Cost			
Description	Region I	Region II	Region III
Space	2,512	2,866	3,140
Equipment	1,811	1,811	1,811
Labor	433	463	514
Supplies	41	44	46
Total Annual cost - State-of-the-art (1976)	4,797	5,184	5,511

Forecast Annual Cost			
Description	Region I	Region II	Region III
Space (S.O.A. cost x 1.84)	4,622	5,273	5,778
Equipment (S.O.A. cost x 1.70)	3,079	3,079	3,079
Labor (S.O.A. cost x 1.90)	823	880	977
Supplies (S.O.A. cost x 1.58)	63	70	73
Total annual cost - Forecast (1986)	8,589	9,302	9,907

FORECAST COST SUMMARY
(Thousands of dollars)

Flow path 11

Throughput volume (No. of depots) 1

State-of-the-Art Annual Cost			
Description	Region I	Region II	Region III
Space	24,396	28,392	31,096
Equipment	20,246	20,506	20,622
Labor	42,791	45,290	49,963
Supplies	2,386	2,553	2,829
Total Annual cost - State-of-the-art (1976)	90,319	96,741	104,510

Forecast Annual Cost			
Description	Region I	Region II	Region III
Space (S.O.A. cost x 1.84)	45,809	52,241	57,217
Equipment (S.O.A. cost x 1.70)	34,419	34,860	35,057
Labor (S.O.A. cost x 1.90)	81,302	86,051	94,929
Supplies (S.O.A. cost x 1.58)	3,770	4,033	4,470
Total annual cost - Forecast (1986)	165,300	177,185	191,673

FORECAST COST SUMMARY
(Thousands of dollars)

Flow path 11

Throughput volume (No. of depots) 40

State-of-the-Art Annual Cost			
Description	Region I	Region II	Region III
Space	628	710	778
Equipment	1,150	1,160	1,163
Labor	910	974	1,080
Supplies	63	67	75
Total Annual cost - State-of-the-art (1976)	2,751	2,911	3,096

Forecast Annual Cost			
Description	Region I	Region II	Region III
Space (S.O.A. cost x 1.84)	1,154	1,307	1,432
Equipment (S.O.A. cost x 1.70)	1,956	1,972	1,977
Labor (S.O.A. cost x 1.90)	1,729	1,850	2,053
Supplies (S.O.A. cost x 1.58)	99	106	118
Total annual cost - forecast (1986)	4,938	5,235	5,580

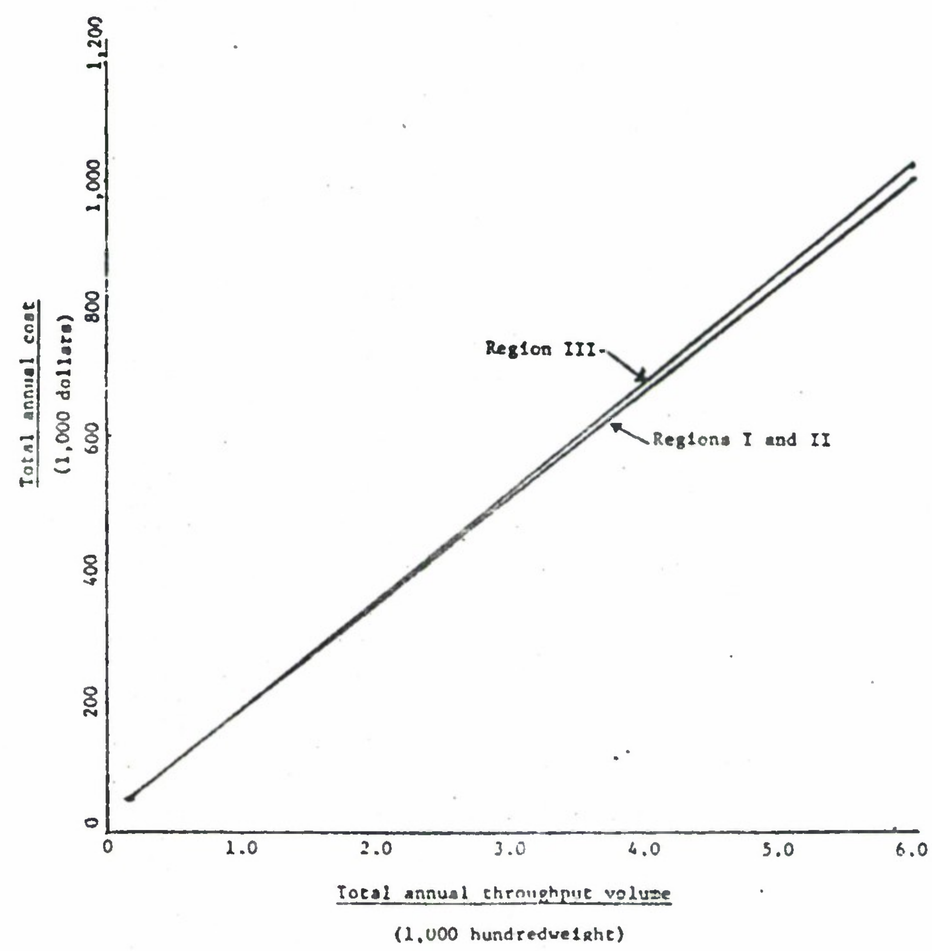
EXHIBIT E

FORECAST COST CURVES

Annual forecast direct variable costs are shown graphically in this Exhibit for each flow path. Annual cost values at maximum and minimum throughput levels are those developed by application of forecast cost factors to state-of-the-art annual costs. Intermediate cost values are derived by assuming a linear relationship between cost and throughput over the entire throughput range.

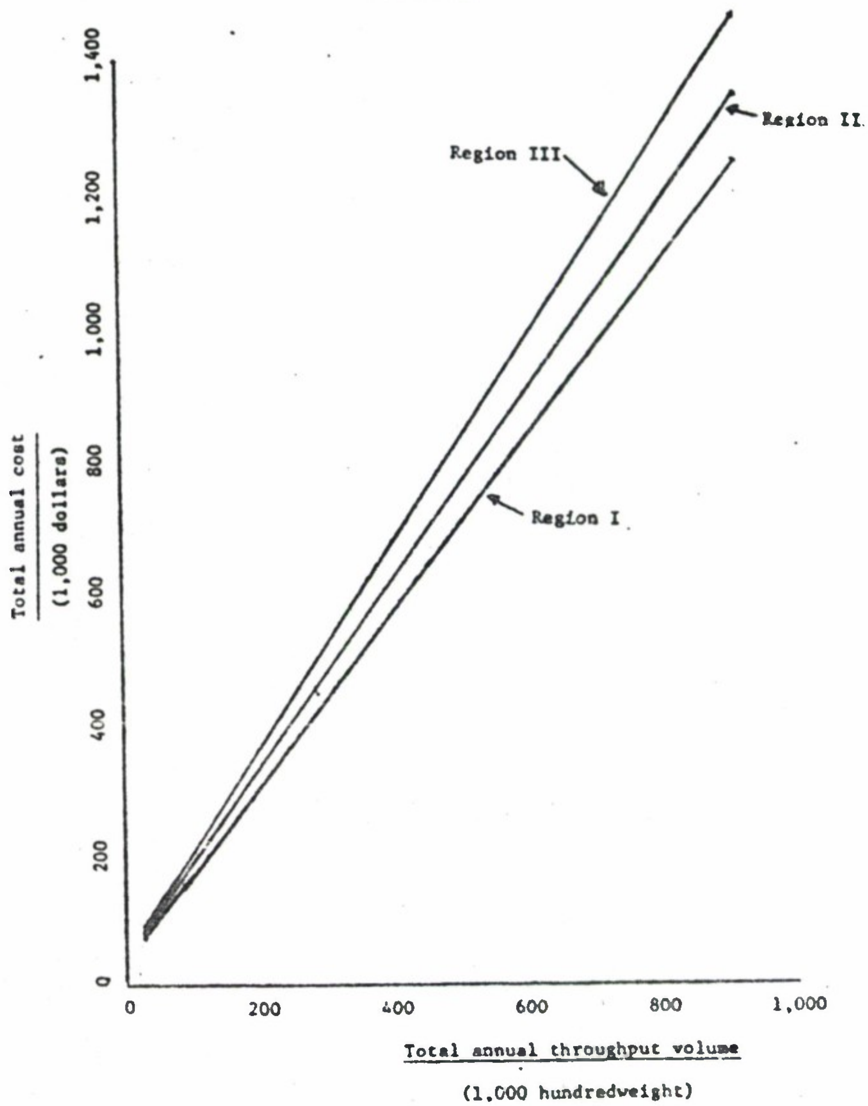
Forecast Cost Curve

Flow Path 1



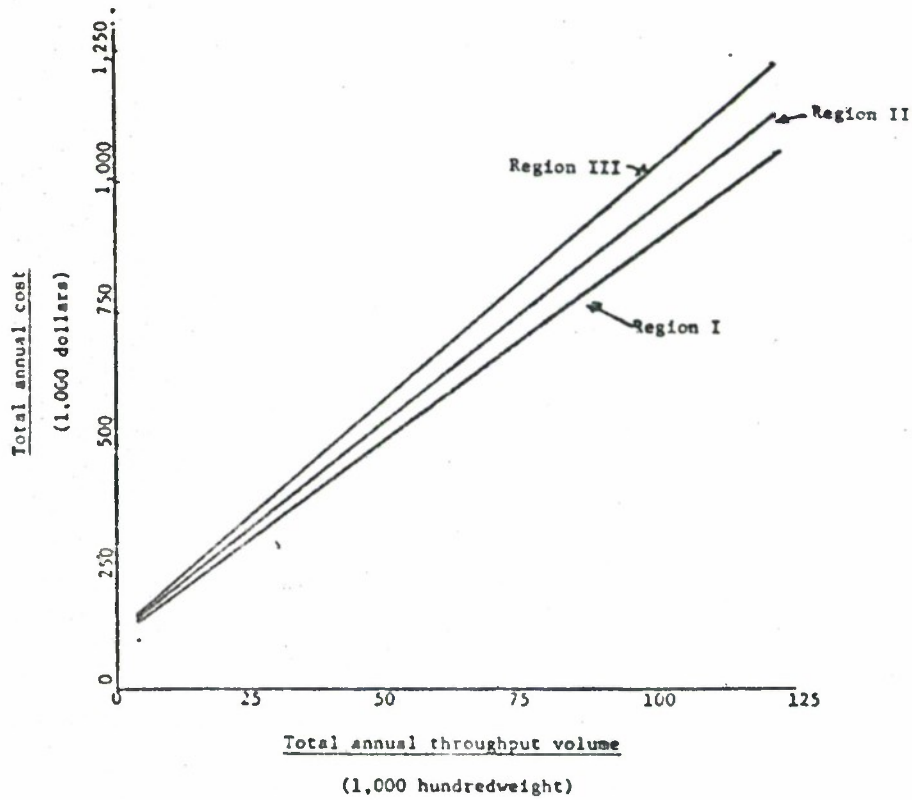
Forecast Cost Curve

Flow Path 2



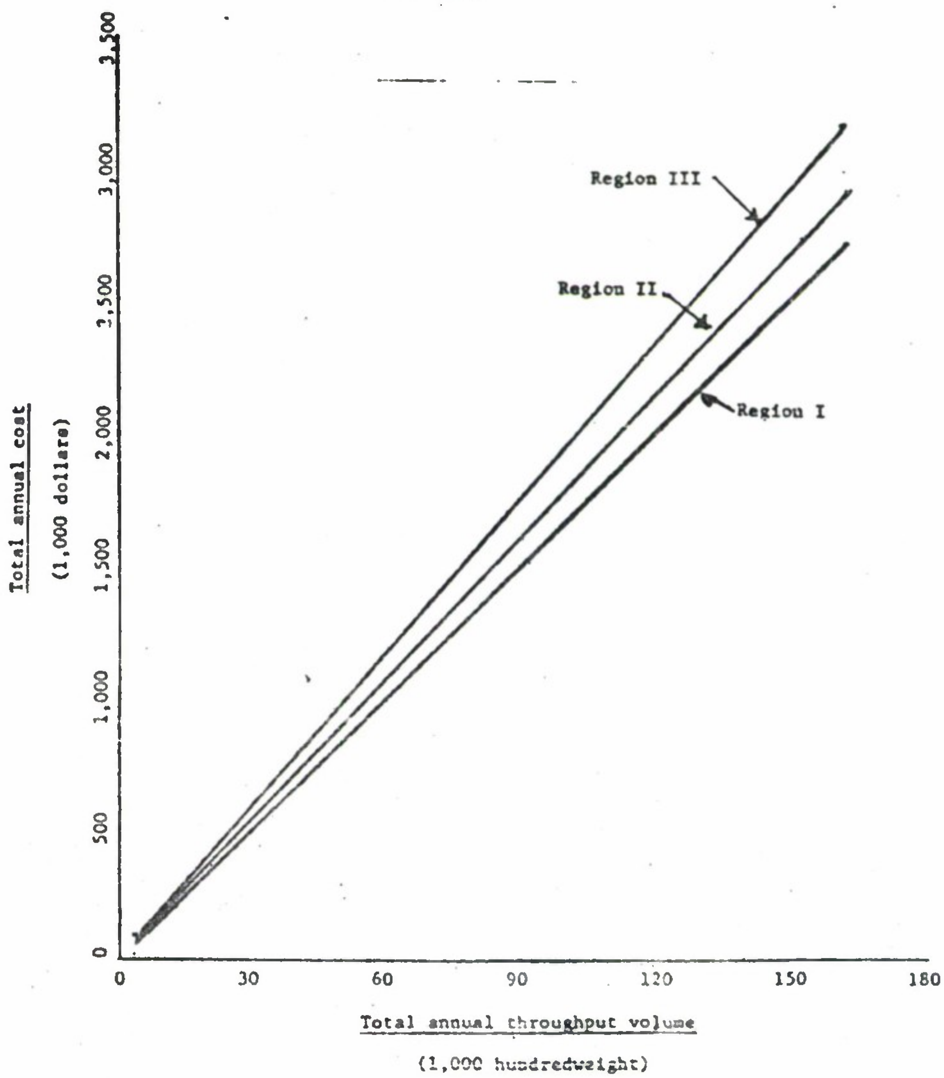
Forecast Cost Curve

Flow Path 3



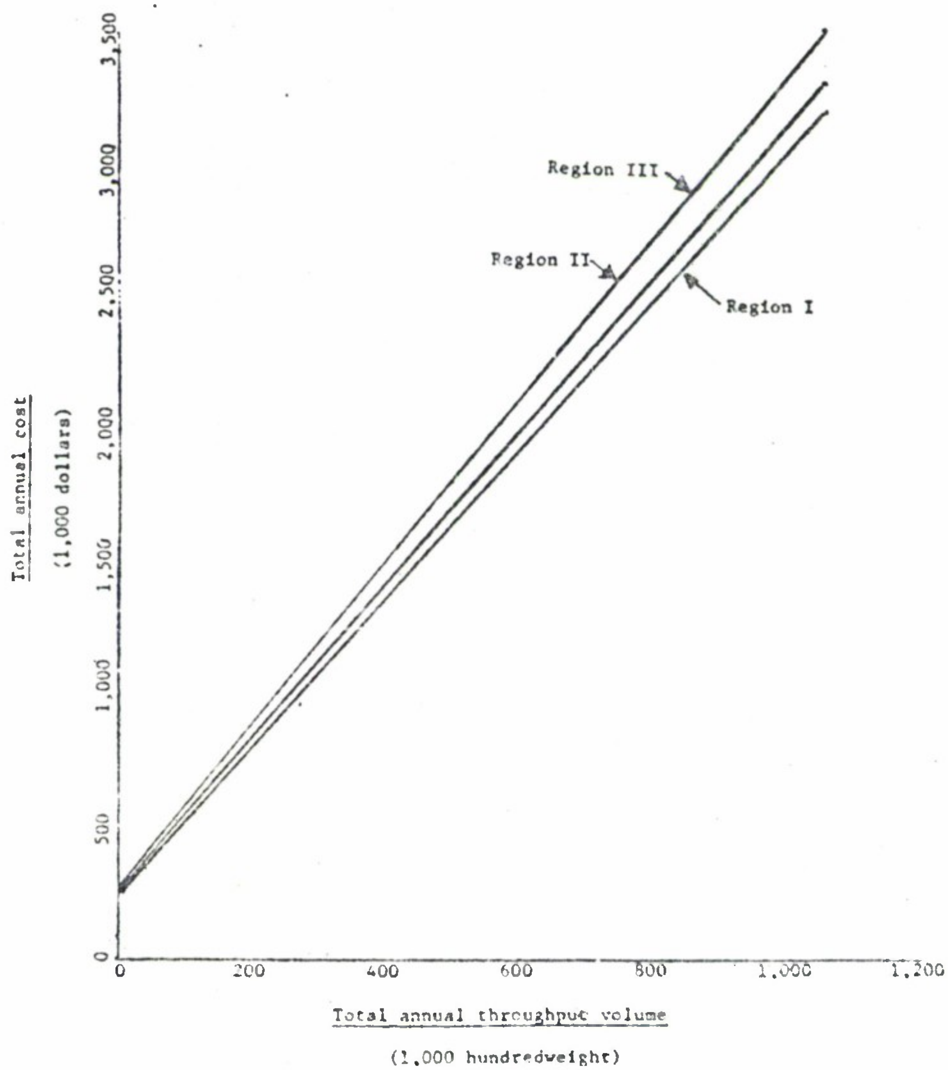
Forecast Cost Curve

Flow Path 4



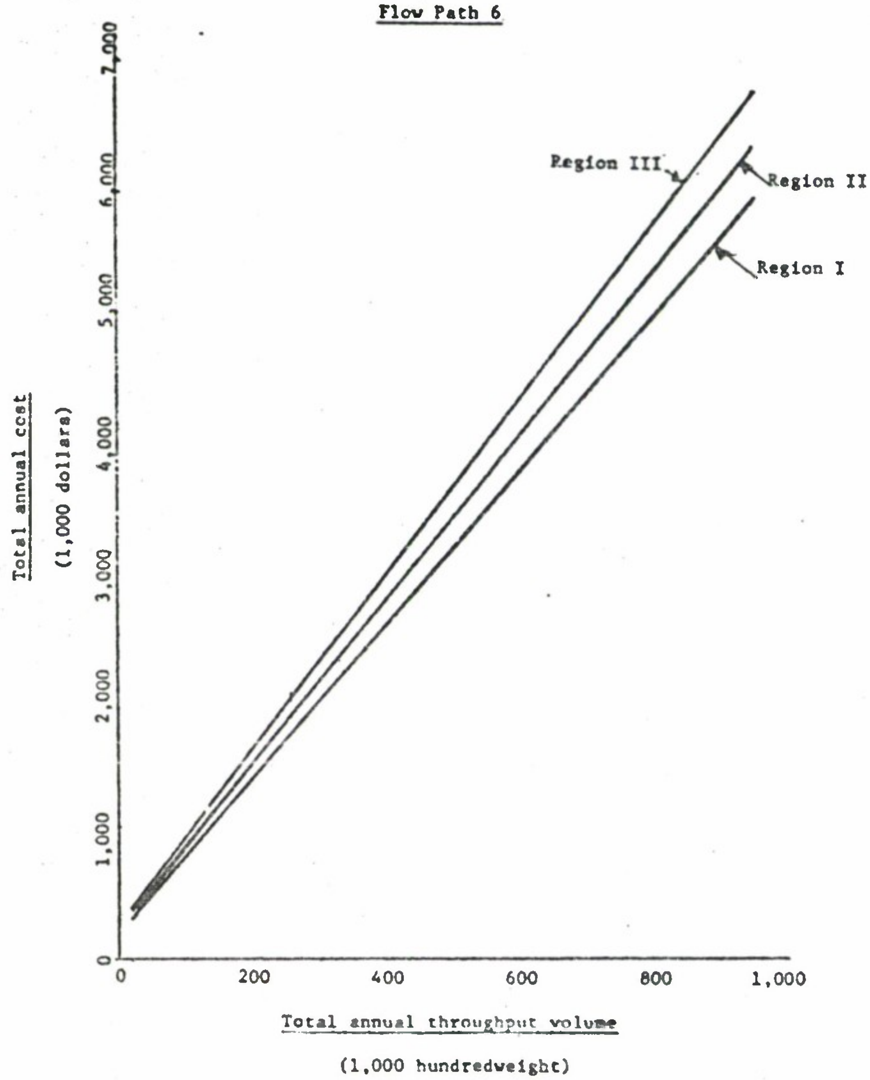
Forecast Cost Curve

Flow Path 5



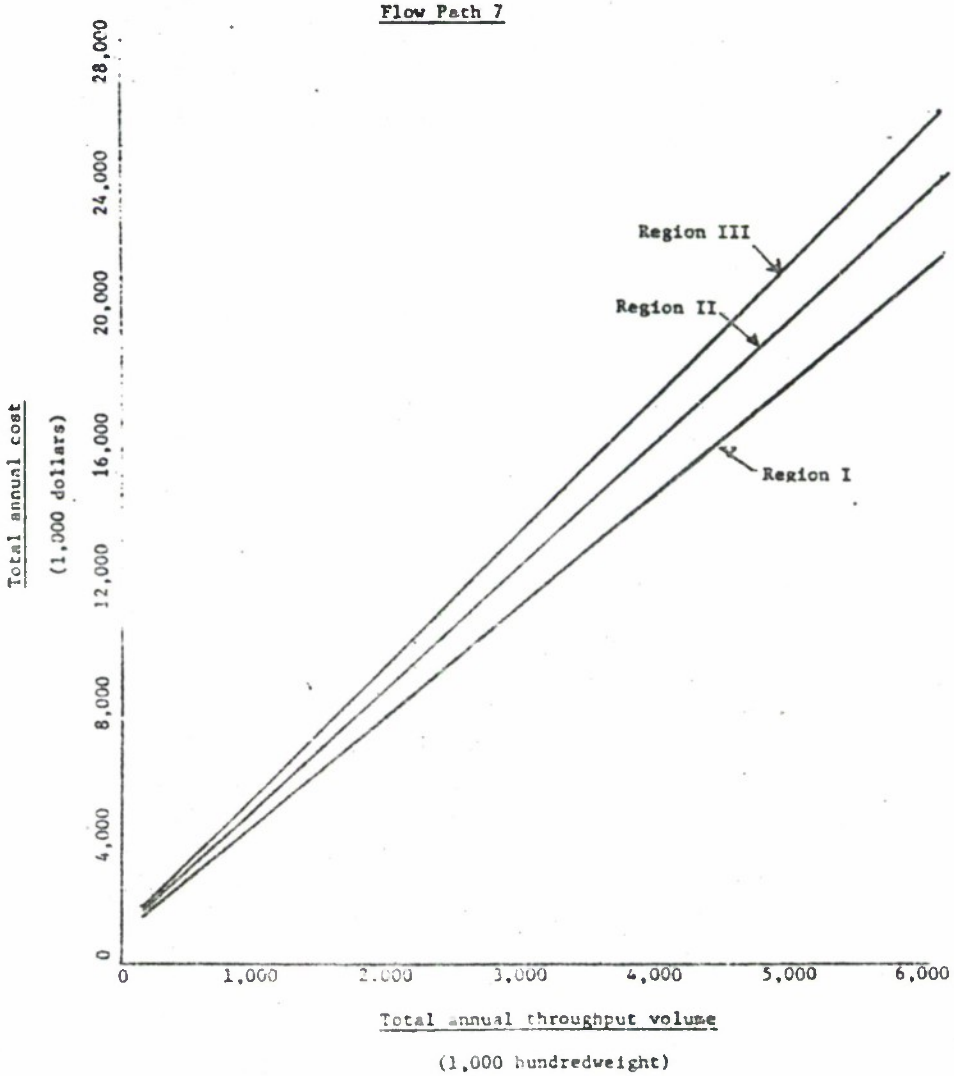
Forecast Cost Curve

Flow Path 6



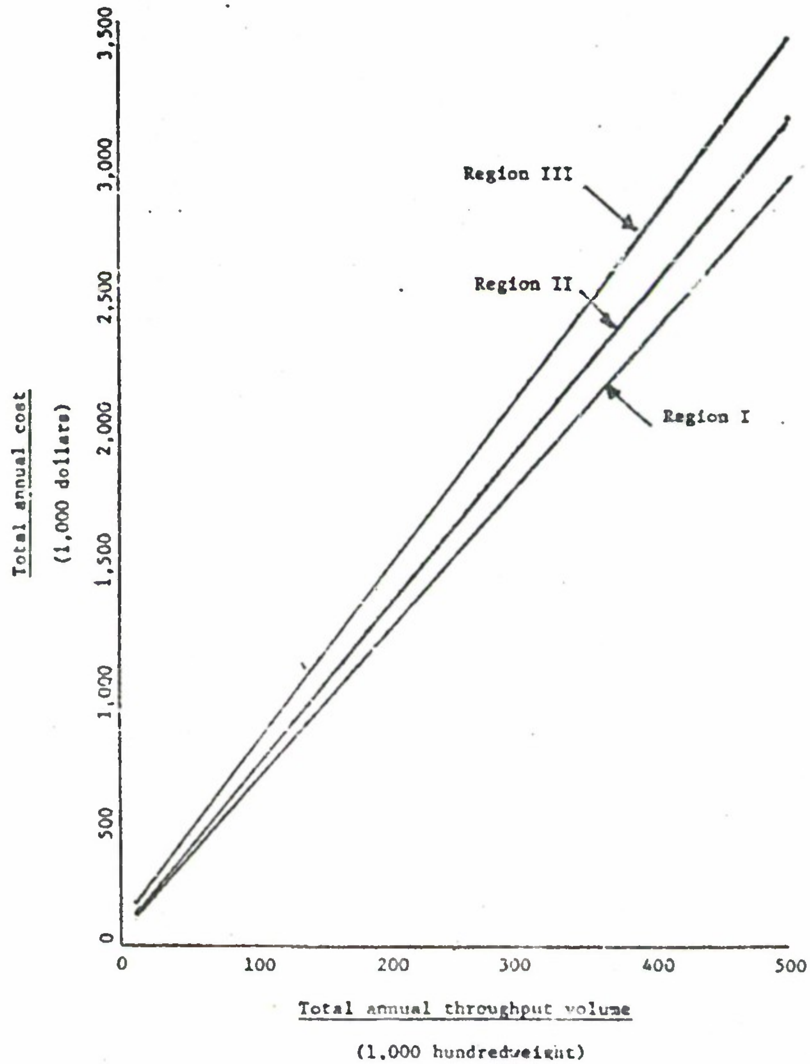
Forecast Cost Curve

Flow Path 7



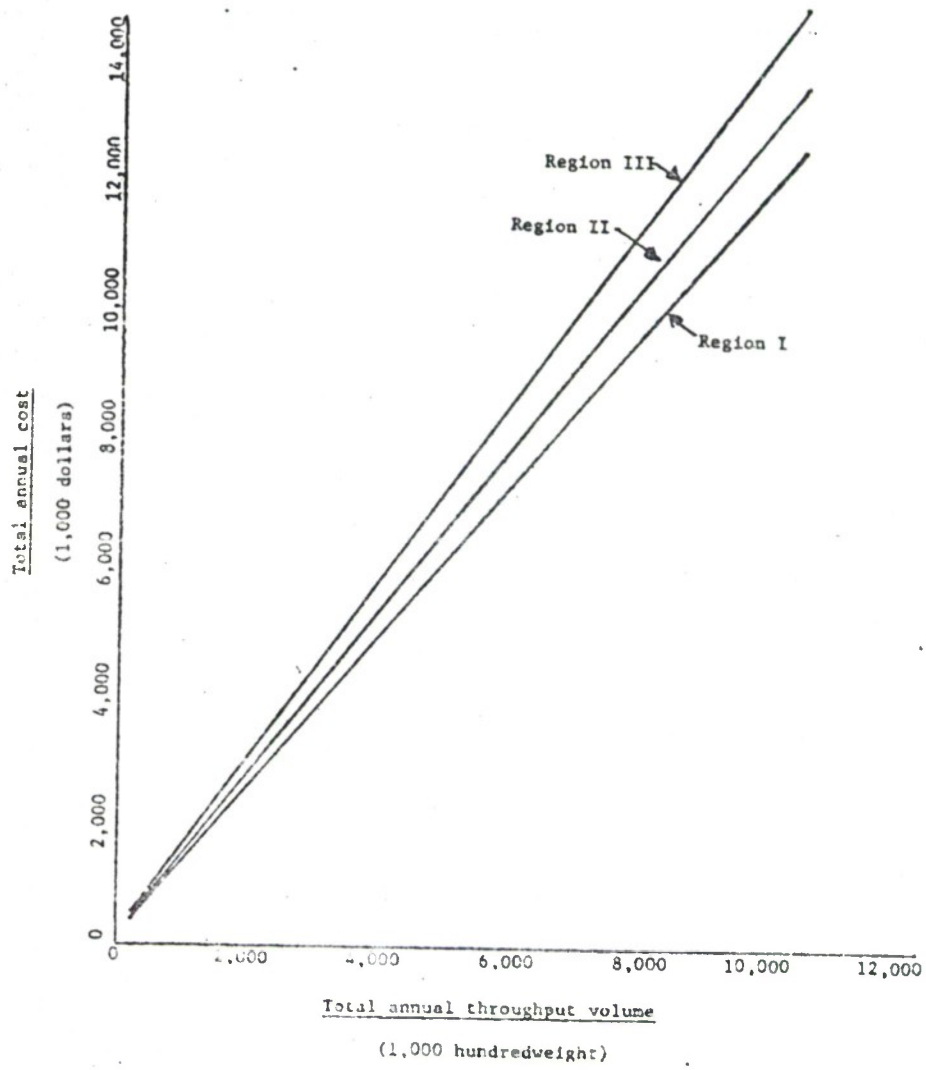
Forecast Cost Curve

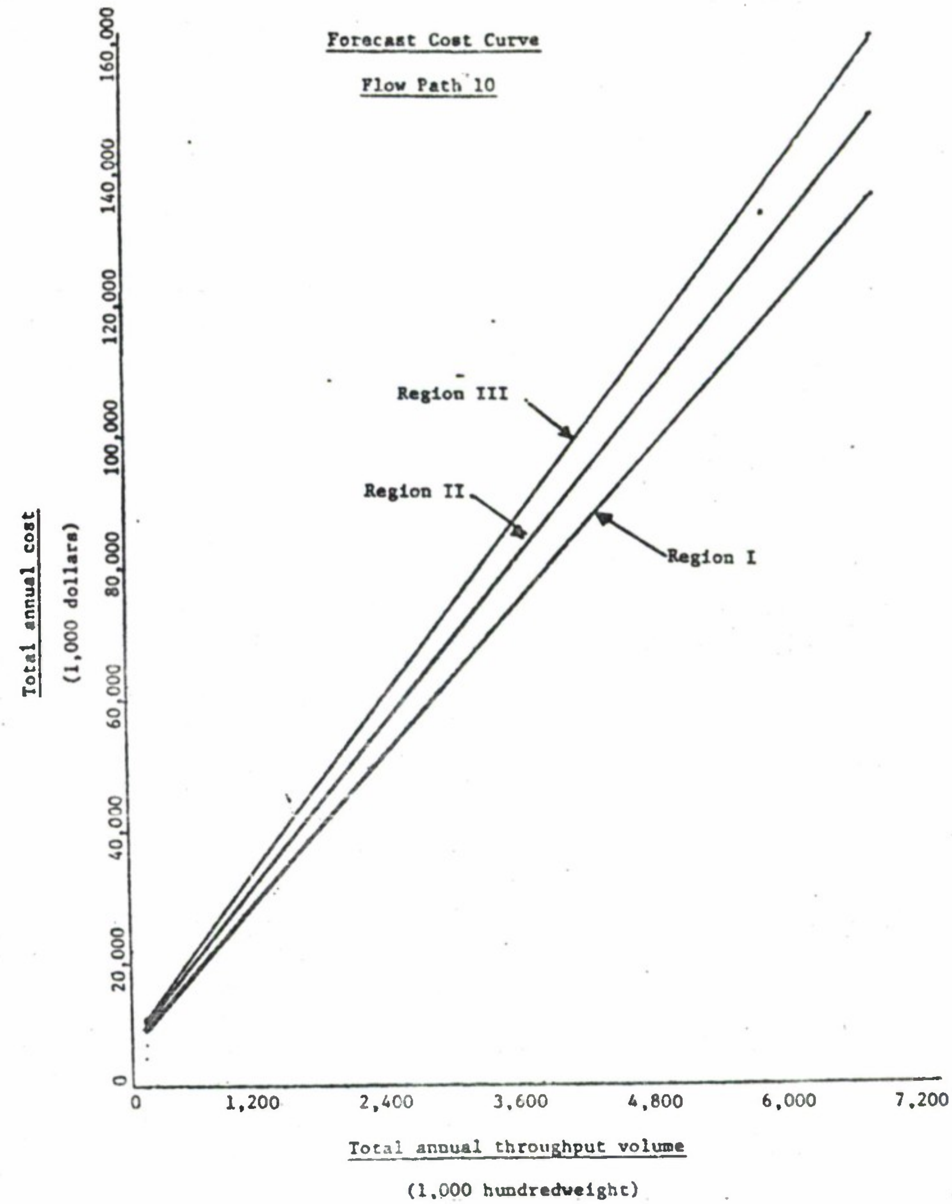
Flow Path 8

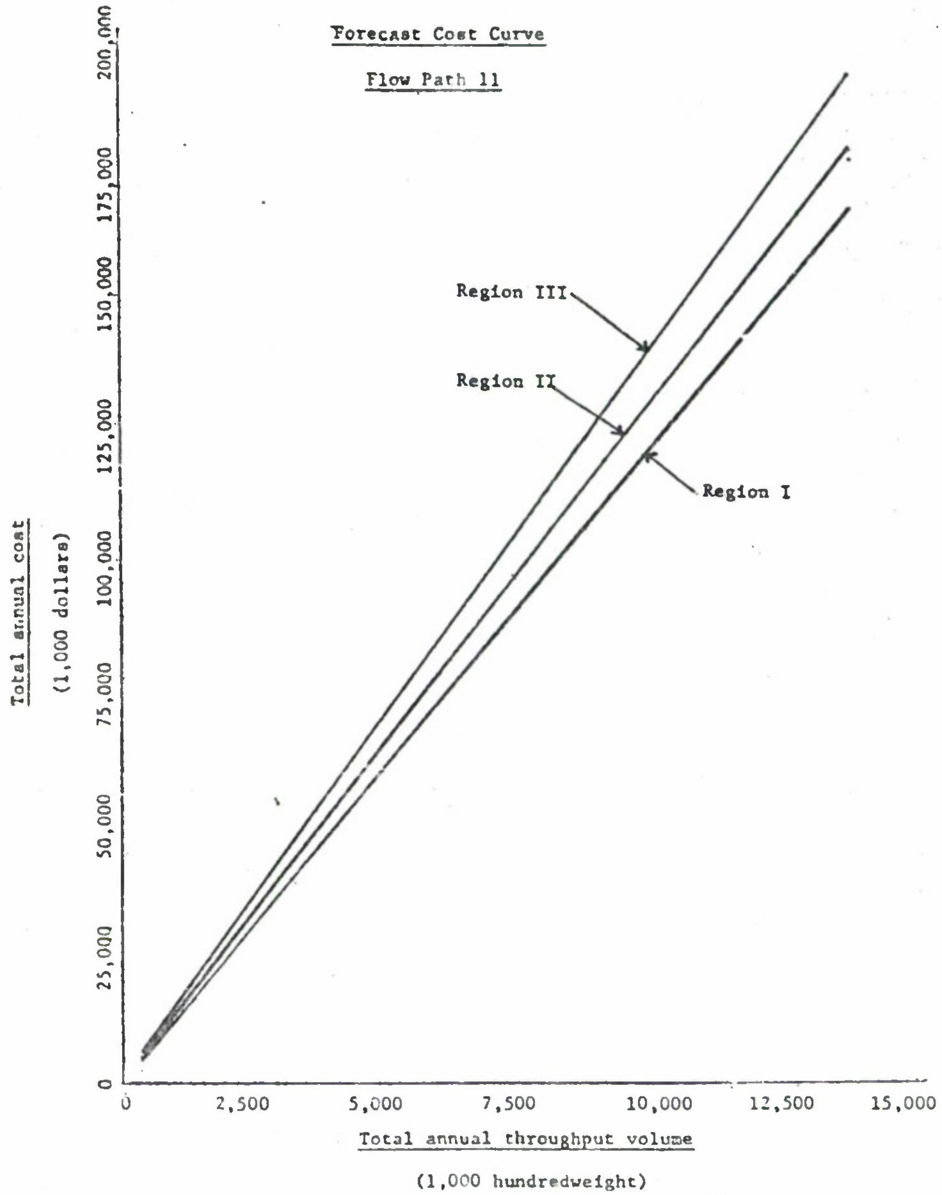


Forecast Cost Curve

Flow Path 9




Forecast Cost Curve
Flow Path 10
Region III
Region II
Region I
Total annual cost
(1,000 dollars)
0
20,000
40,000
60,000
80,000
100,000
120,000
140,000
160,000
0
1,200
2,400
3,600
4,800
6,000
7,200
Total annual throughput volume
(1,000 hundredweight)


Forecast Cost Curve
Flow Path 11
Region III
Region II
Region I
Total annual cost
(1,000 dollars)
0
25,000
50,000
75,000
100,000
125,000
150,000
175,000
200,000
0
2,500
5,000
7,500
10,000
12,500
15,000
Total annual throughput volume
(1,000 hundredweight)

END

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